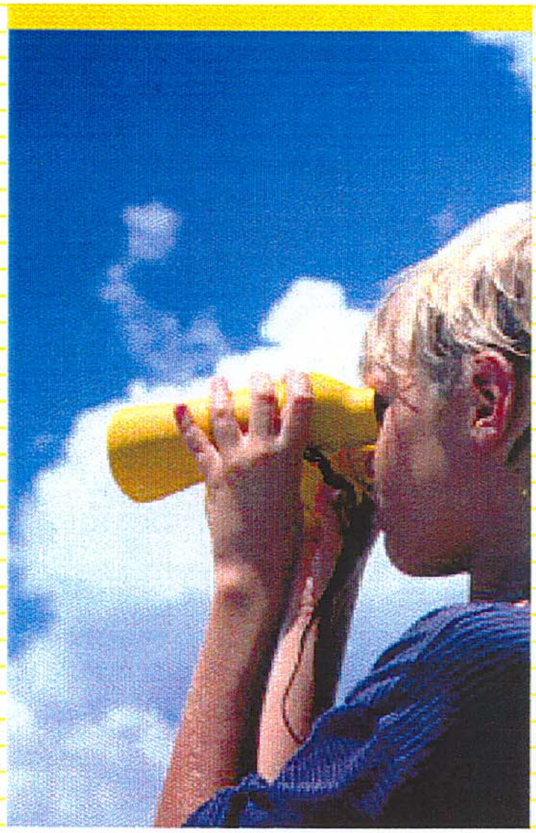
Exploring Technology

A Standards-Based Middle School Model Course Guide



ITEA-CATTS Consortium

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Table of Contents

Preface

This guide presents a model for a standards-based contemporary technology education course for the middle level. This model course guide features an exploratory curriculum thrust for a cornerstone middle level course. Course content is based on International Technology Education Association (ITEA) Technology for All Americans Project publications, *Rationale and Structure for the Study of Technology* (ITEA, 1996), and *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy/STL)* (ITEA, 2000). Also, if your state has standards for technology education, it will be important to correlate those standards with the standards for technological literacy.

The ITEA-CATTS Consortium has also produced standards-based documents that should be consulted: *A Guide to Develop Standards-Based Curriculum for K-12 Technology Education* (ITEA, 1999) and *Teaching Technology: Middle School* (ITEA, 2000). This course model incorporates contemporary methods and strategies recommended in the latter publication. Methods and activities are intended to support the learning of what is important to know and be able to do in the study of technology. Teachers, department chairpersons, and supervisors are encouraged to review these publications prior to using this guide in order to understand the foundations and research-based content upon which this publication is based.

Contents of This Guide

This guide provides a model for developing and implementing a technology education course at the middle school level. This publication will assist classroom teachers and developers in making informed decisions about appropriate content, methods and activities, assessment strategies, and resources for an effective technology education course. Chapter 1 addresses the nature of the learner at the middle level, the nature of learning environments and the curriculum thrust for the study of technology. Chapter 2 provides the model course framework and suggested content and activities for the contemporary units. Various contexts are provided to engage students actively in applying the content and processes of technology. Content and activities are closely aligned with technology standards and benchmarks. Connections to other content areas are cited. Strategies for 9, 18, and 36-week scheduling schemes are presented. In Chapter 3, a glossary and recommended resources provide supplementary information for this guide.

How to Use This Guide

This course, *Exploring Technology*, is organized around a curriculum design framework developed by Grant Wiggins and Jay McTighe. The process, referred to as "backward design" is thoroughly explained in their book, *Understanding by Design*, published in 1998 by the Association for Supervision and Curriculum Development (ASCD). Of particular importance is that this process is based on standards-driven curriculum. The technology teacher is encouraged to read the book to get a deeper understanding of this curriculum design process. Since this course guide has been written using this design model, a brief overview of the premises for designing this curriculum resource will be covered in Chapter 1.

Technology Education curriculum may be organized around a series of activities that may or may not contribute to an overarching theme. This course provides a conceptual approach to developing standards-based curriculum. In essence, rather than beginning with activities and learning experiences, the overall desired results, i.e. what you want the students to know and be able to do, are addressed first. The desired results are derived from the standards for technological literacy and benchmarks as well as standards developed by individual states. The next step is determining the acceptable evidence, specific knowledge, and actions found in the corresponding benchmarks that indicate whether students have truly understood and met the initial results. Finally, learning experiences (activities, lessons, demonstrations, presentations, etc.) are provided to lead students toward attaining the acceptable evidence (standards and benchmarks) that meets the desired results (attainment of standards).

Exploring Technology
Technological Literacy Content Standards Matrix**

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Standard #1	✓		✓	✓	✓
Standard #2		✓			✓
Standard #3		✓		✓	
Standard #4				✓	
Standard #5					✓
Standard #6					✓
Standard #7	✓				
Standard #8		✓			
Standard #9					✓
Standard #10	✓				
Standard #11		✓			
Standard #12					✓
Standard #13					✓
Standard #14				✓	
Standard #15			✓		
Standard #16			✓		
Standard #17			✓	✓	
Standard #18			✓	✓	
Standard #19			✓		
Standard #20			✓	✓	

**Standards are described in detail in *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000).

Compendium of Major Topics for Standards for Technological Literacy: Content for the Study of Technology

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Nature of Technology				
Standard 1: The Characteristics and Scope of Technology	• Natural world and human-made world • People and technology	• Things found in nature and in the human-made world • Tools, materials, and skills • Creative thinking	• Usefulness of technology • Development of technology • Human creativity and motivation • Product demand	• Nature of technology • Rate of technological diffusion • Goal-directed research • Commercialization of technology
Standard 2: The Core Concepts of Technology	• Systems • Resources • Processes	• Systems • Resources • Requirements • Processes	• Systems • Resources • Requirements • Trade-offs • Processes • Controls	• Systems • Resources • Requirements • Optimization and Trade-offs • Processes • Controls
Standard 3: The Relationships Among Technologies and the Connections Between Technology and Other Fields	• Connections between technology and other subjects	• Technologies integrated • Relationships between technology and other fields of study	• Interaction of systems • Interrelation of technological environments • Knowledge from other fields of study and technology	• Technology transfer • Innovation and Invention • Knowledge protection and patents • Technological knowledge and advances of science and mathematics and vice versa
Technology and Society				
Standard 4: The Cultural, Social, Economic, and Political Effects of Technology	• Helpful or harmful	• Good and bad effects • Unintended consequences	• Attitudes toward development and use • Impacts and consequences • Ethical issues • Influences on economy, politics, and culture	• Rapid or gradual changes • Trade-offs and effects • Ethical implications • Cultural, social, economic, and political changes

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Technology and Society, continued				
Standard 5: The Effects of Technology on the Environment	• Reuse and/or recycling of materials	• Recycling and disposal of waste • Affects environment in good and bad ways	• Management of waste • Technologies repair damage • Environmental vs. economic concerns	• Conservation • Reduce resource use • Monitor environment • Alignment of natural and technological processes • Reduce negative consequences of technology • Decisions and trade-offs
Standard 6: The Role of Society in the Development and Use of Technology	• Needs and wants of individuals	• Changing needs and wants • Expansion or limitation of development	• Development driven by demands, values, and interests • Inventions and innovations • Social and cultural priorities • Acceptance and use of products and systems	• Different cultures and technologies • Development decisions • Factors affecting designs and demands of technologies
Standard 7: The Influence of Technology on History	• Ways people have lived and worked	• Tools for food, clothing, and protection	• Processes of inventions and innovations • Specialization of labor • Evolution of techniques, measurement, and resources • Technological and scientific knowledge	• Evolutionary development of technology • Dramatic changes in society • History of technology • Early technological history • The Iron Age • The Middle Ages • The Renaissance • The Industrial Revolution • The Information Age
Design				
Standard 8: The Attributes of Design	• Everyone can design • Design is a creative process	• Definitions of design • Requirements of design	• Design leads to useful products and systems • There is no perfect design • Requirements	• The design process • Design problems are usually not clear • Designs need to be refined • Requirements
Standard 9: Engineering Design	• Engineering design process • Expressing design ideas to others	• Engineering design process • Creativity and considering all ideas • Models	• Iteration • Brainstorming • Modeling, testing, evaluating, and modifying	• Design principles • Influence of personal characteristics • Prototypes • Factors in engineering design

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Design, continued				
Standard 10: The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving	• Asking questions and making observations • All products need to be maintained	• Troubleshooting • Invention and innovation • Experimentation	• Troubleshooting • Invention and innovation • Experimentation	• Research and development • Researching technological problems • Not all problems are technological or can be solved • Multidisciplinary approach
Abilities for a Technological World				
Standard 11: Apply the Design Process	• Solve problems through design • Build something • Investigate how things are made	• Collecting information • Visualize a solution • Test and evaluate solutions • Improve a design	• Apply design process • Identify criteria and constraints • Model a solution to a problem • Test and evaluate • Make a product or system	• Identify a design problem • Identify criteria and constraints • Refine the design • Evaluate the design • Develop a product or system using quality control • Reevaluate final solution(s)
Standard 12: Use and Maintain Technological Products and Systems	• Discover how things work • Use tools correctly and safely • Recognize and use everyday symbols	• Follow step-by-step instructions • Select and safely use tools • Use computers to access and organize information • Use common symbols	• Use information to see how things work • Safely use tools to diagnose, adjust, and repair • Use computers and calculators • Operate systems	• Document and communicate processes and procedures • Diagnose a malfunctioning system • Troubleshoot and maintain systems • Operate and maintain systems • Use computers to communicate
Standard 13: Assess the Impact of Products and Systems	• Collect information about everyday products • Determine the qualities of a product	• Use information to identify patterns • Assess the influence of technology • Examine trade-offs	• Design and use instruments to collect data • Use collected data to find trends • Identify trends • Interpret and evaluate accuracy of information	• Collect information and judge its quality • Synthesize data to draw conclusions • Employ assessment techniques • Design forecasting techniques

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
The Designed World				
Standard 14: Medical Technologies	• Vaccinations • Medicine • Products to take care of people and their belongings	• Vaccines and medicine • Development of devices to repair or replace certain parts of the body • Use of products and systems to inform	• Advances and innovations in medical technologies • Sanitation processes • Immunology • Awareness about genetic engineering	• Medical technologies for prevention and rehabilitation • Telemedicine • Genetic therapeutics • Biochemistry
Standard 15: Agricultural and Related Biotechnologies	• Technologies in agriculture • Tools and materials for use in ecosystems	• Artificial ecosystems • Agriculture wastes • Processes in agriculture	• Technological advances in agriculture • Specialized equipment and practices • Biotechnology and agriculture • Artificial ecosystems and management • Development of refrigeration, freezing, dehydration, preservation, and irradiation	• Agricultural products and systems • Biotechnology • Conservation • Engineering design and management of ecosystems
Standard 16: Energy and Power Technologies	• Energy comes in many forms • Energy should not be wasted	• Energy comes in different forms • Tools, machines, products, and systems use energy to do work	• Energy is the capacity to do work • Energy can be used to do work using many processes • Power is the rate at which energy is converted from one form to another • Power systems • Efficiency and conservation	• Law of Conservation of energy • Energy sources • Second Law of Thermodynamics • Renewable and non-renewable forms of energy • Power systems are a source, a process, and a load
Standard 17: Information and Communication Technologies	• Information • Communication • Symbols	• Processing information • Many sources of information • Communication • Symbols	• Information and communication systems • Communication systems encode, transmit, and receive information • Factors influencing the design of a message • Language of technology	• Parts of information and communication systems • Information and communication systems • The purpose of information and communication technology • Communication systems and sub-systems • Many ways of communicating • Communication through symbols

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
The Designed World, continued				
Standard 18: Transportation Technologies	• Transportation system • Individuals and goods • Care of transportation products and systems	• Transportation system use • Transportation systems and sub-systems	• Design and operation of transportation systems • Subsystems of transportation system • Governmental regulations • Transportation processes	• Relationship of transportation and other technologies • Intermodalism • Transportation services and methods • Positive and negative impacts of transportation systems • Transportation processes and efficiency
Standard 19: Manufacturing Technologies	• Manufacturing systems • Design of products	• Natural materials • Manufacturing processes • Consumption of goods • Chemical technologies	• Manufacturing systems • Manufacturing goods • Manufacturing processes • Chemical technologies • Materials use • Marketing products	• Servicing and obsolescence • Materials • Durable or non-durable goods • Manufacturing systems • Interchangeability of parts • Chemical technologies • Marketing products
Standard 20: Construction Technologies	• Different types of buildings • How parts of buildings fit	• Modern communities • Structures • Systems used	• Construction designs • Foundations • Purpose of structures • Buildings systems and sub-systems	• Infrastructure • Construction processes and procedures • Requirements • Maintenance, alterations, and renovation • Prefabricated materials

Chapter 1

Technology Education and the Middle Level Learner

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Technology Education and the Middle Level Learner

Middle Level Learner: In Transition

Middle school students are not characterized in terms of "typical." During the middle school years students are going through cognitive, social, moral, and physical developmental changes brought on by adolescence. These changes affect the way students view peers, teachers, school, and themselves. Piaget (1983) described these children as either at the concrete operational (7 to 11 years) or the formal operational (11 years and above) stage. During the concrete operational phase, students are aware of choices to solutions and perceive events as a systematic process. In the formal operational years, students are able to conceptualize, make logical deductions, and apply a systematic approach to solving problems. It is at these two stages of development that many children begin and finish middle school. The middle school teacher must understand these developmental changes and the actions and reactions they produce. This will directly influence the methods of instruction, activities, and assessments that are utilized.

Middle school students have been negatively described as cruel, poor at decision making, inappropriate at socializing, non-risk-takers, lacking self-confidence, and often not good at making friends. Conversely, these same children have been shown to be caring, helpful, energetic, willing to learn, imaginative, and exciting to be around. The differences are accurate and mostly depend upon the students' maturity level, gender, personality, and motivation. These unpredictable behaviors make the middle school experience as much of a challenge for the teacher as the student. The cognitive and intellectual skills that develop during the middle school years not only influence the manner in which youngsters deal with academic situations, but they also influence the adolescent's ability to examine his/her sense of self and his/her relations with others. In fact, reflections on self and relationships may be dominant to almost any other issues in the adolescent's life. Middle school youngsters increasingly turn toward their peer group for acceptance and less toward their parents. While this does not happen suddenly, gradually the adolescent becomes more self-directing. Failing to navigate these stages successfully can result in a number of potential risks.

Kohut (1988) said about middle school children, "While often displaying somewhat emotionally erratic, inconsistent, and unpredictable behavior, the transescent is highly dependent on peer group acceptance and praise rather than adult approval" (p. 7). As a result of these various changes, students tend to relate more to others of their age rather than teachers or parents. The National Middle School Association believes that responsive middle level schools are characterized by educators committed to young adolescents, a shared vision, high expectations for all, an adult advocate for every student, family and community partnerships, and an integrated curriculum. Therefore, a developmentally responsive middle school program would provide:

- educators who are knowledgeable about adolescents
- a positive school climate
- programs that foster health, wellness, and safety in a balanced curriculum
- assessment and evaluation that promote learning
- a variety of organizational arrangements
- varied instructional strategies
- a variety of exploratory opportunities.

Some of this inconsistent behavior can be attributed to their limited span of attention. Rottier and Ogan (1991) stated that middle school students "have a span of attention between 7 to 12 minutes" (p. 17). With this short period of time it is easy to see why middle school children easily become bored and frustrated in a classroom that uses lecture and note-taking as the primary instructional strategy. In technology education, students have an opportunity to be active both physically and cognitively. Not only are they using their hands to construct a product or system, but also they must use higher-order thinking skills to solve complex technological problems.

Cooperative learning has also been found to be successful with middle school children. Wood (1987) described ways to foster cooperative learning into the middle school classroom. Among the items that were suggested are various methodologies, grouping techniques, promoting social interaction, and a synthesis of cooperative learning research. His research showed that students have benefited from cooperative learning by having:

1. "Higher motivation to learn and greater intrinsic motivation;
2. More positive attitudes toward instruction and the instructors;
3. Improved relationships of both tutor and tutee;
4. Increased self-esteem;
5. More positive perceptions about the intentions of others;
6. A decrease in competitive goal structures;
7. Greater acceptance of differences;
8. A decrease of dependence on the teacher" (pp. 11-12).

Ferguson (1989-90) described four reasons why cooperative learning would be appropriate at the middle school. First, cooperative learning has a solid theoretical and empirical research base. Studies have shown positive results for students at all grade levels, in most subjects, from diverse backgrounds, and in a large number of school settings. Also, cooperative learning is effective at assisting students in the areas previously mentioned. Second, cooperative learning is consistent with the cognitive and social objectives for middle school students. Next, cooperative learning has been shown to be effective with middle school children while providing an "excellent entré into the broader arena of small group learning, an important component of exemplary middle school instruction" (p. 24). Fourth, Ferguson found cooperative learning is ideal for inexperienced teachers in transposing theory into practice.

Technology Education for the Middle Level

Technology education can have a significant positive impact on children at the middle school level. Learning experiences need to have a balance of thinking and psychomotor skill development. Brainstorming ideas, making sketches, using tools, reading directions, pondering, manipulating various materials, refining a solution to make it better, and writing conclusions are all aspects of a quality middle school technology education program.

Technology education curriculum in grades 6-8 focuses on exploration and engagement. The middle level curriculum is derived from early adolescent concerns and compelling issues in the larger world. The curriculum should encourage the learner to investigate, examine, try out, and inspect concepts related to technological systems. By exploring and becoming engaged in design, problem solving, and technological systems, the learner is able to further uncover and evolve personal interests and abilities related to a continuum of careers and educational programs.

The middle school years afford greater involvement in the planning and execution of designs for technological systems. Students at this level can engage in decision making involving critical and creative thinking to construct effective and efficient solutions. In grades 6-8 technology education activities, students create and improve upon designs and make constructive decisions. Through planned experiences, they will solve practical problems in a variety of contexts and be able to evaluate solutions for effectiveness. Technology education courses engage students in a well-planned instructional sequence that builds on K-5 experiences and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students will be able to communicate their ideas verbally and visually, and document the development of their plans through visual representation, journals, and portfolios. Teaming, peer monitoring, and individual actions contribute to student achievements at this level.

In *Exploring Technology*, middle level students develop an understanding of the progression and scope of technology through exploratory experiences. In group and individual activities, students experience ways in which technological knowledge and processes contribute to effective designs and solutions to technological problems. This course is a cornerstone for a middle level technology education program. Other suggested courses for the middle level are:

- *Innovation and Engineering Design*
  Innovations, or commercially produced inventions, affect us personally, socially, and economically. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Brainstorming, visualizing, modeling, constructing, testing, and refining designs provide firsthand opportunities for students to understand the uses and impacts of innovations. Students develop skills in communicating design information and reporting results.
- *Technological Systems*
  Students become acquainted with content and processes associated with basic technological systems. The design, development, and relationships of different systems are explored. Students apply systems concepts to design and problem-solving activities related to transportation, information, energy/power, biotechnology, and other technological systems. Laboratory activities engage students in constructing, using, and assessing technological systems.

Technology Education Curriculum Criteria

Quality technology education curricula reflect best educational practices and foster student achievement. Such curricula promote technological literacy through challenging activities that stimulate student thinking and appropriate actions concerning developing, using, and managing technology. This model course exhibits these criteria:

- *Focuses on students and their learning*: Teaching and learning activities focus on student-generated knowledge, inquiry, reasoning, and design and problem-solving processes to produce logical, effective designs and engineered solutions.
- *Reflects exemplary practices for teaching and learning:* Incorporates best practices to stimulate student interest and confidence in technological studies, develop technological literacy, and enhance student achievement.
- *Emphasizes design and problem-solving activities*: Provides multi-sensory experiences based on technological knowledge,

processes, and contexts. Students create design plans, engage in design and problem-solving processes, and systematically evaluate the effectiveness of designs and solutions to practical problems.

- *Contributes to standards attainment*: Planned student experiences contribute to achieving standards for technology education content, processes, and contexts at respective grade levels.
- *Develops technological literacy*: Promotes technological literacy and student achievement through organized and sequenced experiences.
- *Integrates math, science, and other subjects*: Makes purposeful content connections with other school subjects to broaden students' understanding of technology.
- *Promotes careers in professional and technical fields*: Develops career awareness in technology and engineering fields, with exploration of career paths, analyses of career options, and development of transferable career skills.

*Taken from *A Guide to Develop Standards-Based Curriculum for K-12 Technology Education* (ITEA, 1999).

Summary

This model course guide reflects contemporary technology education content and instructional practices. It is based on research in education and related to the study of technology in schools. *Exploring Technology* is standards-based and student-centered, addressing technology as a dynamic subject with real-world relevance. The framework that follows provides guidance to teachers for implementing this technology education course at the middle level. Teachers, supervisors, and curriculum developers are encouraged to consult the additional resources cited in this publication for further guidance.

Course Framework

Each unit begins with a general scenario that provides the context for studying technology content. These scenarios were selected based on the diverse experience they afford to students and for their ability to engage students in challenging activities that correspond to the standards. The scenarios can be modified slightly by the teacher to align more closely with local initiatives and/or situations. Although the scenario itself may not initially interest all students, the activities and challenges contained in that unit will spark their natural curiosity to solve technological problems.

Next, the standards, benchmarks, and learning experiences are identified to provide guidance in planning and implementing the unit. Table 1 provides an overview and description of each section.

Unit Specifications	Description
Desired Results	**Technological Literacy Standard -** Indicates what the student will know and be able to do as a result of studying the unit. **Technological Literacy Benchmark -** Indicates specifically what students will need to know and do in order to attain the standards.
Acceptable Evidence	Identifies what students will need to do to demonstrate that they have attained the standards. Using more than one assessment method for a standard provides a more complete picture of a student's abilities.
Suggested Learning Experiences	Specifies what students will be doing and incorporates a variety of technological experiences and integrated content from other academic areas.

Table 1: Exploring Technology Unit Specifications

Identifying Desired Results: Content Standards

When desired results are considered, it is important to identify the aspects of the curriculum that would be characterized as "enduring" understandings. These understandings are the standards developed by the International Technology Education Association, as well as state, provincial, or local standards. This guide will be using *STL*, although other standards can be incorporated. To further define the enduring understandings, what is important for students to know and be able to do is identified. The *STL* benchmarks can be used to assist in this step. Wiggins and McTighe (1998) indicate that "student learning is incomplete if the unit or course concluded without mastery of these essentials [important knowledge and skills]" (p. 9).

The technology education teacher should begin by indicating which standards should be targeted during the course. Although many of the standards will be covered in every course in some fashion, only a few will be the central focus of the course. Next, examine the benchmarks for the standard statements. The standards and benchmarks provide guidance for content and assessment.

Desired Results
➘ Acceptable Evidence
➘ Learning Experiences

Assessment: Determining Acceptable Evidence

The next step is to determine what evidence will be gathered to prove the student has achieved a particular benchmark leading toward a standard. It forces the teacher to consider assessment criteria and strategies before developing activities. Table 2 identifies a variety of assessment techniques that are applicable in a technology education classroom. Although this list is not exhaustive, it does serve as a beginning point for assessing the benchmarks to determine if students have attained a particular standard. To have a complete "picture" of a student's abilities, a variety of assessment techniques should be employed. Appropriate assessment methods should be identified for each of the standards. For instance, a multiple-choice test would not provide quality evidence that a student can utilize the design process to solve technological problems. In the same respect, a checklist may not be an appropriate method to determine if students understand the impacts of various inventions on society and the environment. The *Teaching Technology: Middle School*, Method 9: Standards-Based Student Assessment provides a strong overview of how assessment can be conducted in a technology education classroom.

Assessment Technique	Description
True/False	Students are given a statement and asked to indicate whether it is correct or incorrect. Having students describe how to make the "False" statement "True" can enhance this technique.
Matching	Two lists are given. Items from one list are correctly matched with items from the other list. For an additional challenge, have the first list contain items that are not used or are used twice.
Multiple-choice	Students are given a choice of three to five answers and must select the correct response. Answers should challenge students to find the "best" answer rather than the only "correct" response.
Fill-in-the-blank	A statement is given with one or more words missing, and the student must write in the correct response.
Short Answer	A statement or question is given that requires students to write a brief response. Students should provide details that support their answers.
Essay	A multi-paragraph answer is given to answer the posed question. The response requires the student to synthesize and draw conclusions to formulate an answer.
Checklist	With a predetermined list of performances, the teacher places a checkmark next to the items a student completes.
Observation	The teacher makes anecdotal notes based on what the student does. The student may or may not be aware that the observation is occurring.
Project/Model/Simulation	The student designs, constructs, and tests an object that is used to solve a technological problem.
Performance Task Demonstration	Students must perform a task or series of tasks correctly and safely.
Oral/Multimedia Presentation	Information is shared with a group of students in the form of a speech or electronic presentation.
Portfolio/Journal/Log	The student compiles a systematic and organized collection of his/her work and documents it for others to view.

Table 2: Assessment Techniques

Planning Learning Experiences and Instruction

The final step in this course framework is to determine what type of learning experiences can be utilized or designed so the students can meet the standards. Technology education teachers have typically done very well at planning activities and learning experiences. It is these learning experiences that are essential when creating a quality standards-based curriculum. Teachers are cautioned not to go backward in the process at this time and begin to change the acceptable evidence or desired results if certain activities that they have done in the past do not fit into appropriate learning experiences.

What makes an activity a technology education activity that is standards-based? Technology education is a unique area of study in every student's educational experience and therefore the aspects that are found in a technology activity are somewhat different from those found in other academic areas. Levande (1998) identified eight items that are important to consider when creating technology activities for a standards-based curriculum. These are: problem solving, planning, construction, feedback, redesign, content, authenticity, and impact consideration.

Problem solving is a key thinking skill in technology education. Although other academic subjects advocate problem solving, they usually refer to it in different contexts than technology education. Mathematical problem solving involves solving the *computational aspect* of a real-world problem as students investigate questions, tasks, and situations according to the suggestions given by the teacher. It also differs from scientific problem solving, sometimes called scientific inquiry, where methods of inquiry, observation of natural phenomenon, the scientific method, and a focus on knowing are paramount. In technology education, problem solving involves having the students create a solution to a technological problem. By allowing students to apply problem-solving techniques to real problems, they are able to see application for the content that is being learned. Emphasis on developing solutions to problems in the human-made world, applying problem-solving strategies, and a focus on "doing" characterize technological problem solving.

Planning is another factor that should be considered in technology activities. While students proceed with solving the problem, planning must occur. Resources such as people, information, materials, energy, capital, and time need to be considered. Students should be sure to document their planning by creating a portfolio that shows their work, making sketches and drawings of potential solutions, selecting proper tools and materials appropriately, and by keeping a log or journal. *Teaching Technology: Middle School,* Method 8: Using Concept Maps™ to Facilitate Learning can be adapted for the planning process. Concept maps allow students to brainstorm for ideas and then connect them into a logical pattern.

Construction involves changing the physical or chemical characteristics of a material. This may involve using a variety of tools and machines with different materials and processes. When students construct, they build a solution to a given problem, safely use tools and machines, and when necessary use a troubleshooting procedure if the solution does not function.

Feedback is a necessary component of the learning experience. Students and teachers need to know the skills and knowledge that have been achieved and to what level of literacy or competency. During and at the completion of the activity, students should review their work habits and processes to determine how they could be improved. Feedback involves having students examine their work habits and progress, determine if the final result matches the desired result, and test and evaluate the solution. Student-to-student, student-to-teacher, and student-to-other-adult feedback is possible.

Redesign is an important part of technology activities. No final solution, regardless of whether it is in education or society, is perfect upon its completion. Redesign is undertaken after students have finished the solution and then have an opportunity to examine their solution, determine how it could be improved, and make those improvements. When a solution is redesigned, others should constructively critique the final solution, provide an opportunity to improve the solution, recognize that no solution is perfect, and examine the potential trade-offs of the solution.

Content is the information that is studied within the field of technology. It involves the study of the history and nature of technology, consideration of future trends and impacts, and academic connections to other fields of study. Content should be based on the standards for technological literacy.

Authenticity refers to making sure the problem to be solved is either real or simulated. Students need to experience and realize that technology in the classroom mimics the real world and that the principles they use to solve the problem are similar to those a technologist uses to solve a problem that has a practical solution. A technologist uses contemporary tools, materials, and processes to solve problems. The same consideration should be given to the tools, materials, and processes that students use.

All technology has planned and unplanned, expected and unexpected consequences. *Impact Consideration* accounts for how the solution may impact the world in which we live. This aspect of the technology activity should be considered as the problem begins. Impact consideration has also been referred to as "technology assessment." Regardless of the terminology, students need to be engaged in "an act of appraising the value of a technological innovation or invention as to its worth to society as well as incorporating the social, economic, and environmental impacts that it may have" (Ritz & Swail, 1994, p. 53).

Developing the Instruction

Once appropriate technology activities have been identified, the instructional technique used to deliver the content and develop skills must be carefully explained. This final section describes six techniques identified by Daniels and Bizer (1998) as best practices in the classroom. These six methods are integrative units, small group activities, representing-to-learn, classroom workshop, authentic experiences, and reflective assessment. These methods span all curriculum and grade levels. In technology education, many of these methods are commonly used due to the nature of the curriculum. It is very important that technology teachers utilize as many of these best practices as possible in order to assist as many students as possible to become technologically literate.

Integrative Units involve combining content to make the learning more meaningful and relevant. Content studied in segmented units is quite unlike the structure in the real world. People do not work on math for thirty minutes, then shift to science, to English, to technology education, then to social studies. Rather, their daily activity is an integrated use of all these subjects.

One of the main benefits of a middle school program is that there is some flexibility built into the daily schedule so teachers can work together to provide a more cohesive curriculum. In technology education, there has also been a segmentation of knowledge and skills according to courses. This best practice of integrated units can also be done in the regular technology classroom. If students are completing an activity in rocketry, they will also be learning valuable information from science about space travel, gravity, weather consideration for launch, supplying oxygen in space, and much more. In mathematics, students determine payload weight, angle of flight into orbit, estimation, and mathematical problem solving. This approach gives students a more realistic perception of technology and its impacts on many different areas.

Small-Group Activities make the learning very realistic. Although students should not focus on developing skill and knowledge in only one technology area, usually students will come to enjoy one study of technology more than others. It therefore makes sense to group students together when doing a technological activity. Cooperative learning helps students learn more, develop better social skills, become more interested in school, and develop teamwork as a lifelong skill. In *Teaching Technology: Middle School*, Method 3: Cooperative Learning, Teamwork, and Leadership gives an overview of how to effectively utilize small-group activities in a technology education classroom.

Representing-to-Learn may not be as familiar to technology teachers as it is to those in language arts. Writing-to-learn is the idea that writing can be a tool of thinking as well as the finished product. This premise can also extend into other areas such as drawing, sketching, mapping, and other graphic representations. In technology education, students should keep a log that documents their work, sketches of their ideas, and notes about how to perform a particular process. The more students can document their ideas, the more thinking they do and, eventually, the more technologically literate they become. Method 6: Sharing, Reporting, and Recording Information in *Teaching Technology: Middle School* can be utilized effectively when representing-to-learn.

Classroom Workshop is used when small groups are given instruction, as they need to know the content. "A defining element of a true workshop is choice: individual students choose their own … projects for investigation" (Zemelman, Daniels, and Hyde, 1998, p. 198). In technology education, students should be able to choose the solution to a particular problem and even search to find the technological problem. This simple idea of choice is a major shift from the assigned projects that were given in traditional industrial arts classrooms. In technology, students should develop an ability to critically examine the world around them and search for ways that new technology can improve the way of life. By doing classroom workshops, it also means that not every student may need to watch a demonstration of a particular machine if their chosen solution does not involve it. For this technique to be successful, teachers must also be good classroom managers so students who are not part of the workshop are quiet, safe, and responsible.

Authentic Experiences reinforce the fact that technology is real, and the activities that students work on should also be real. Simulating a given situation (landing on the moon) or actually being involved in that situation can show this "realness." *Teaching Technology: Middle School* Method 7: Using Simulations to Teach Technology gives a good background for how to integrate simulations in technology education. Regardless of the mode of reality, if students see a connection to the world in which they live, their interest peaks, they are more willing to participate, and even their behavior improves. The authors suggest these ways to create a more authentic classroom:

- Have newspaper and magazines about technology readily available for students to use, and tie them into the curriculum.
- Invite guest speakers who are involved in technology each day.
- Favor learning-by-doing over learning-by-just-sitting-there-quietly-and-listening.
- Let students form groups.
- Conduct one-to-one conferences with students.
- Become involved in the Technology Student Association or other student leadership/co-curricular program.
- Reach out to the community as a class.

Finally, *Reflective Assessment* occurs as students complete an activity. It is important for them to look back to determine the quality of their work and processes that were used to solve the problem. Allow students to evaluate themselves. "One of the most promising mechanisms for authentic evaluation is the student portfolio, a folder in which students save selected samples of their best work in a given subject" (Zemelman, Daniels, & Hyde, 1998, p. 207). By completing a portfolio, students have an opportunity to document the steps they followed to solve a particular problem. In the United Kingdom, portfolios are commonly found in design and technology classrooms.

In addition to the six methods just identified, *Teaching Technology: Middle School* describes other methods of teaching standards-based curriculum in technology education. The technology teacher should reference this publication as well as the book, *Methods that Matter,* by Daniels and Bizer.

> "A key trait of effective thinkers, writers, problem solvers, readers, researchers, and other learners is that they constantly self-monitor and self-evaluate."

Unit Framework

Understanding how this entire curriculum is organized is essential to using this guide. The following sections will be contained in the units for this course as they are explained below:

Enduring Results, *STL* Standards and Benchmarks

This section identifies the relevant standards for developing technological literacy. This section is the crux of the entire unit and the foundation by which each was designed and organized. When reviewing the unit, do not give these items a cursory overview; rather, spend time developing an understanding of their significance. Since each unit is supported by these standards, as you read the unit and have questions of relevancy or content, refer back to this section to see the basis from which it was developed.

The Benchmarks portion of this section provides detailed information concerning what students will need to know and be able to do to attain the standards. The benchmarks provide additional guidance for developing content in each unit.

Acceptable Evidence

The standards and benchmarks do not stand by themselves. The evidence that students produce to show they have achieved the standards is identified in this section. The teacher is free to add other assessment techniques to this section as long as a variety of methods are evident and it supports the standards.

Unit Overview

A narrative of each unit is given in this section overview. This overview provides teachers with some material they can use to introduce the unit, utilize the learning experiences, conduct assessments, and maintain the flow of the class. It will be important that as this section is read, the learning experiences and standards be reviewed at the same time. This provides a complete picture for the teacher.

Learning Experiences

A variety of activity ideas have been given for the technology teacher to use. Many of them refer the teacher to other sources for more information. With a little planning and thoughtfulness, the material given can be used to develop quality standards-based activities. The teacher is cautioned not to change the activities without referring to the standards at the start of the unit. If this standards connection is lost, the entire unit begins to lose its connectivity and richness. Other activities may be added to this list as long as they are based on the standards. The references at the end of the activities can be correlated with the resources found in Chapter 3.

Content Outline

The content outline provides direction for the teacher as the unit progresses. Examples and references to the learning experiences support the outline headings. This information may also be used in a course of study if a particular school district or state requires such information.

Academic Connections

In each unit, there are several general examples of content from other academic areas that can be readily integrated into the unit. The information given is only a beginning, since additional material will emerge as the unit progresses. Teachers are encouraged to obtain current textbooks being used in their school as references for their classrooms and to interact with the teachers of these subjects. Some Internet sites have been given to provide background information about the particular topic.

The Internet sites listed have been reviewed and contain educationally appropriate material. Be advised that web addresses change frequently, and that in the future these sites may not be available or the same. To prevent sites from changing from time-to-time, consider saving them to a hard drive for future reference. By doing this, if the site does move or is changed beyond the scope of the unit, an original still resides. For some sites it may be necessary to ask permission before saving their sites, and for all sites it is courteous to ask permission to save. Finally, remember that the Internet is a research tool, much like an encyclopedia, and it should never replace the teacher.

Exploring Technology Unit Framework

This curriculum document has been organized to address specific standards. There are two units that begin the course: Technological Innovation and Technological Design. The length of each unit varies from 3 to 6 weeks depending on the number and depth of learning experiences that are given. If the technology education program is intended to be six, nine, or twelve weeks in length, then each of these units should be covered. Longer courses should include at least one of the Technological Theme Units: Scope of Technology, Technological Integration, and Explorations in Technology. These also vary in length from 6 to 12 weeks, depending on the depth and number of learning experiences. The chart below identifies a sample unit configuration for these course lengths, although this may vary depending on the scheduling organization in your school.

Course Length	*Units to cover* Option 1	*Units to cover* Option 2
6 Weeks	Technological Innovation (3 weeks) Technological Design (3 weeks)	Technological Innovation (3 weeks) Technological Design (3 weeks)
9 Weeks	Technological Innovation (3 weeks) Technological Design (3 weeks) Scope of Technology (3 weeks)*	Technological Innovation (5 weeks) Technological Design (4 weeks)
12 Weeks	Technological Innovation (3 weeks) Technological Design (3 weeks) Scope of Technology (3 weeks)* Explorations in Technology (3 weeks)*	Technological Innovation (3 weeks) Technological Design (3 weeks) Scope of Technology (6 weeks)
18 Weeks	Technological Innovation (3 weeks) Technological Design (3 weeks) Scope of Technology (6 weeks) Technological Integration (6 weeks)	Technological Innovation (5 weeks) Technological Design (4 weeks) Scope of Technology (9 weeks) OR Technological Integration (9 weeks)
36 Weeks	Technological Innovation (3 weeks) Technological Design (3 weeks) Scope of Technology (6 weeks) Technological Integration (12 weeks) Explorations in Technology (12 weeks)	Technological Innovation (5 weeks) Technological Design (4 weeks) Scope of Technology (9 weeks) Technological Integration (9 weeks) Explorations in Technology (9 weeks)

***This unit must be abbreviated.**

Resources

This list contains books, videos, magazines, and other materials that may assist in the unit. All of these items do not need to be purchased in order for the course to be successful. Additional reference materials should be added to this list as they become available, as long as they support the standards. Most importantly, the teacher should be familiar with the standards and ITEA-CATTS publications.

Chapter 2

Course Framework and Units of Study

Contemporary Curriculum
for Technological Literacy

Chapter 2

Course Framework and Units of Study

Unit 1: Technological Innovation

This introductory unit provides the students with an overview of technology and its historical influence. Students study specific inventions or innovations to realize their impacts on individuals, society, and the environment over time. Students find out how inventions and innovations have affected the way people live, work, and play.

Enduring Results

***STL* Standards and Benchmarks**

1. Develop an understanding of the characteristics and scope of technology. (Standard #1).
   a. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (Benchmark F).
   b. The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative. (Benchmark G).
   c. Technology is closely linked to creativity, which has resulted in innovation. (Benchmark H).
2. Develop an understanding of the influence of technology on history. (Standard #7).
   a. Many inventions and innovations have evolved using slow and methodical processes of tests and refinements. (Benchmark C).
   b. In the past, an invention or innovation was not usually developed with the knowledge of science. (Benchmark F).
3. Develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (Standard #10).
   a. Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it. (Benchmark G).
   b. Some technological problems are best solved through experimentation. (Benchmark H).

Acceptable Evidence

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. A class presentation or group discussion that describes an invention, the inventor, and the circumstances surrounding its creation.
2. A timeline that traces an invention from its inception to its present day status.
3. A sketchbook that demonstrates how sketching can be used to effectively communicate ideas about inventions and innovations.

Overview

This may be the first unit in technology for many students, especially if there was not a program at the elementary level. As students participate in this unit, it is important for them to realize that inventions and innovations are results of technology. By examining inventions and innovations, students will find out that technology extends far beyond computers or electronic devices and into fields such as agriculture, medicine, and recreation. This unit features activities such as "Inventions All Around" and "The Pencil Invention" to encourage this study.

Once students have understood that inventions cause change, they may study an inventor and invention or innovation of their choice. There are many print and online resources that students can access when conducting this study. It should be stressed to study not only an inventor and resulting invention or innovation, but also what other events were occurring at that time. Events such as a war, economic hardships and prosperity, or new scientific discoveries impact technological development tremendously. One example is the need for faster transportation as families and communities moved westward. The railway system was developed to meet this need. Over time, the railway system began to be used less frequently as automobiles and airplanes were developed. Examples like this one can be used to show that, as better forms of technology emerge, others begin to lose their prominence. The "Biography of an Inventor," "Inventions that Made History," and/or "Future History" activities can be used at this time.

To conclude this unit, students should realize that not all inventions have a positive impact on society. Discuss with the class the basics of nuclear power as a source of electrical energy as well as for medical purposes and for weapons of mass destruction. In 1847, did Alfred Nobel anticipate the impacts of dynamite when experimenting with nitroglycerin? The key point is that inventions and innovations create technological change, sometimes with tremendous benefits, and other times with negative consequences. Students will need to make decisions that have technological implications reaching far beyond their lifetime. The "Robotic Takeover" and/or "Timeline for the History of Technological Artifacts" activities can be used to see how technology impacts our lives.

> "As the 21st century dawns, new technologies will open up possibilities for humankind that have never existed before. This power will bring with it hard choices."
> ***Standards for Technological Literacy***

Suggested Learning Experiences

1. **Timeline for the History of Technological Artifacts** – The material in this activity can be best used during the first few days of class as a means to introduce your students to the broad field of technology. Through this activity, students will learn that a technological artifact is any product or system that extends the ability of humans to modify or change their world. This activity allows students to become aware of the many types of technological artifacts that they use as a first step in studying about technology. (RB-01, Activity 1)

2. **Inventions all Around** - This activity can be organized around a class discussion of various inventions and innovations that are in the classroom or a student's home. Cooperative learning can be used for brainstorming ideas, recording them, and sharing ideas with the rest of the class. The goal is that students can recognize that inventions and innovations cause change. "Inventor's World" has been produced by the National Geographic Society. This website features a variety of inventions, inventors, links to other invention sites, invention games, and links to invention books. http://www.nationalgeographic.com/features/96/inventions/ (TB-13, Chapter 5)

3. **The Pencil Invention** – All students are familiar with a traditional pencil as a basic technological tool. Begin the activity by showing the students a used pencil without an eraser. Students should work independently to come up with ways to improve the pencil. To help students think divergently, remind students that pencils are used in many more places than just schools. For instance, how could the pencil be improved for a museum curator, radio announcer, mountain climber, custodian, or a truck driver? This activity is supported by information at: http://www.noogenesis.com/inventing/pencil/pencil_page.html.

4. **Biography of an Inventor** – Each student will select an inventor and research what that person created and the impacts that his/her inventions had on society and individuals. Inventors and their work can be found in resources such as *Technology's Past: America's Industrial Revolution* and *The People Who Delivered the Goods: Volumes I and II* by Dennis Karwatka (TB-01, Chapter 4)

5. **Inventions that Made History** – Students who experience this activity should understand and appreciate some of the contributions that have resulted from technological developments in the history of the world. They will learn about the need for inventions and the processes used by the inventor. The teacher could locate some

museums that could be visited either in person or on the Internet. Also, commercially produced encyclopedias on CD-ROM provide a rich source of information and illustrations. "Inventors Museum" is a very comprehensive website featuring inventions by females and African-Americans, during the colonial period, for space travel, in communication technology, and many more. Inventions are profiled along with the lives of the inventors so a deeper understanding of them as individuals is possible. http://www.inventorsmuseum.com/maptext.htm (See RB-01, Activity 2)

6. Future History – Each student can select a product and write a short narrative of what the item may be like in 50 years. Also, a narrative may be written to describe the object and how it has changed. Students can create a sketch of the new object as it is today and what it may look like in 50 years. Then they can trace the product back 50 years to determine how it evolved to the present day. Finally, each student could create a timeline to show the 100-year span of the product. These timelines can be placed on a wall to show the inter-relatedness of various inventions. An article written by A. Emerson Wiens in *The Technology Teacher*, Volume 57, Number 3, provides the basis for this activity. For a variation of this activity, see "Future History" on page 211 of the *Design and Technology High School Guide* produced by the Commonwealth of Virginia. In this activity, students use *Sim Earth*, a computerized simulation program, to create a "perfect" living environment.

7. Techno-Pictionary – Each student is given a card on which is written the name of an object related to technology. When it is their turn, they are to sketch the object on the board and see if the class can identify it. This can also be done in small groups, especially as students are just beginning to learn to sketch. The Massachusetts Institute of Technology (MIT) sponsors the "Invention Dimension" website. It features an inventors' handbook for K-12 educators, trivia challenges, featured inventors, descriptions of many inventions and inventors, and contests. http://web.mit.edu/invent/

8. Robotic Takeover? – For this cooperative learning experience, divide the class into four groups. Each group will describe one aspect of technological impact (planned, unplanned, desirable, and undesirable) as it relates to robots in the workplace. A variety of examples should be given. Then form groups that contain one representative from each of the groups and make a poster that shows the technological impacts of robots in the workplace. To better focus the groups, a specific workplace may be given, such as car manufacturing or removing hazardous materials.

These learning experiences were designed to acquaint students with technological innovations. The technology teacher has the option of selecting from comparable activities that:

- Align with technological literacy standards;
- Provide a cohesive structure to the entire curriculum;
- Connect in a variety of ways to technology content, other activities, and to other fields;
- Engage students actively as they design and construct a product or system during the unit.

Content Outline

I. Definitions & Examples

A. Invention – The development of a new product that has never existed

B. Innovation – Improvements or changes made to existing products

C. Discovery – Looking for new relationships and properties of materials

II. Sketching for Communication

A. Purpose of sketching

B. Sketching lines, shapes, and forms

C. Sketching two-dimensional and three-dimensional objects

D. Computerized Sketching using a CAD program

III. Profile of an Inventor

A. Charles Babbage – Between 1832 and 1839 "The Father of Computing" built the analytical engine, which could perform mathematical calculations. He never saw the device accepted by the British government.

B. George Washington Carver – Paints and stains made by soybean oil in 1927

C. Mary Anderson – Windshield Wiper in 1904

D. Mary Kies – First female to receive a patent. It was for a method for weaving straw with silk in 1809.

E. Marjorie Joyner – First female African-American to receive a patent. It was for the permanent wave machine in 1926. This device began a new frontier in hair styling.

F. Samuel Morse – First telegraph built in 1835 and patented in 1854

G. Thomas Edison – Holds more patents than anyone else, 1093 total. He is famous for the light bulb in 1880 and the phonograph in 1878.

IV. Impacts and Consequences

(Nuclear Power for example)

A. Desirable – Good results (More electricity, safer country)

B. Undesirable – Results can be dangerous or harmful to the environment or individuals (Radioactive waste, global danger)

C. Planned – Certain impacts were anticipated initially, whether they were good or bad (more jobs, save natural resources)

D. Unplanned – Impacts that were not anticipated occurred, sometimes for the good and sometimes for the bad (harmful effects to the environment)

V. Impacts of Inventions and Innovations

A. Societal – Faster transportation, telecommunications, easier access to food and supplies

B. Personal – Improved sight, improved health, warmer houses

C. Ecological – More smog, greenhouse effect, recycling, more efficient use of resources

Academic Connections

Mathematics

1. Scale/Proportion – When sketching, students need to be able to determine the size of an object if it is to appear larger or smaller than its actual size. Ratios, fractions, and basic multiplication are necessary understandings for this topic.
   - http://www.iit.edu/~smile/ma8809.html – Learning ratios and proportions through scale drawings
2. Coordinates – As objects are sketched in a three-dimensional area, students should be able to distinguish between the X, Y, and Z-axes. A review of Cartesian coordinates may be necessary.
   - http://www.encyclopedia.com/articles/02358.html – Cartesian coordinates in the Electronic Library
   - http://mathworld.wolfram.com/CartesianCoordinates.html – Eric Weisstein's World of Mathematics

Science

1. Discoveries – Most changes in technology are the result of inventions or innovations whereas discoveries are usually scientifically based. Some scientific discoveries should be discussed when introducing the lesson.
   - http://www.doe.gov/educate/eduus.htm – Listing of scientific discovery museums in the United States
2. Environmental Impacts – The premise that technology causes changes also infers that there are impacts that sometimes affect the environment. Students should know what types of environmental changes have occurred in their community.

Social Sciences

1. Inventions and Inventors – Changes caused by certain inventions have had profound impacts on society. How these inventions have changed the way people live, work, travel, and relax have many societal implications.
    - http://www.nationalgeographic.com/features/96/inventions/ – "Inventor's World" produced by the National Geographic Society
2. Geography – Transportation is quicker and safer and the world is "smaller."
    - http://www.britannica.com/bcom/eb/article/1/0,5716,120011+2,00.html – The geography of primitive transportation
    - http://www.bookitprogram.com/timetran.html – An extensive transportation timeline

Language Arts

1. Sketches, Logs, Journals, or Portfolio – Students need to make written descriptions and annotations on their designs and ideas to further clarify the intended meaning and function.
    - http://www.lacoe.edu/pdc/second/portfolio.html – Basic information about developing student, teacher, and electronic portfolios
2. Class Presentations – For the benefit of all class members, students should present the information they find about a particular inventor or invention. This will necessitate introducing students to basic speech protocol such as eye contact, speaking loudly, and speaking slowly.
    - http://www.abacon.com/pubspeak/ – Public Speaking website by Allyn Bacon
    - http://freenet.edmonton.ab.ca/toast/tips.html – Tips for giving a presentation by Toastmasters

Unit 2: Technological Design

In this unit, students learn about the design process and experience ways technology is developed and used. While progressing through the unit activities, students will understand the relationships between technology and science and how other academic areas are utilized in the design process. Through this integrated learning students gain a better understanding of how to go about transforming their design ideas into a three-dimensional product or solution.

Enduring Results

***STL* Standards and Benchmarks**

1. Develop an understanding of the core concepts of technology. (Standard #2).
   a. Different technologies involve different sets of processes. (Benchmark T).
2. Develop an understanding of relationships among technologies and connections between technology and other fields of study. (Standard #3).
   a. A product, system, or environment developed for one setting may be applied to another setting. (Benchmark E).
   b. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (Benchmark F).
3. Develop an understanding of the attributes of design. (Standard #8).
   a. Design is a creative planning process that leads to useful products and systems. (Benchmark E).
   b. There is no perfect design. (Benchmark F).
4. Develop abilities to apply the design process. (Standard #11).
   a. Apply a design process to solve problems in and beyond the laboratory-classroom. (Benchmark H).

Acceptable Evidence

1. When given a particular product or system, students should identify the scientific, technological, and other academic information needed for it to function.
2. Students will document their work in a portfolio or log while completing the steps in the design process.
3. Students will produce a solution to a given technological problem, independently or cooperatively, by effectively using resources.

Overview

Previously, students learned about inventions and innovations and that technology creates change in society, individuals, and the environment. Also, students examined impacts and consequences of technology. In this unit, students begin to use the design process to solve a technological problem. When introducing the design process, students should be aware of the relationships between science and technology. Students will learn that, in science, the scientific method is used to answer questions that originate in the natural world. For instance, why do leaves change color in autumn? What type of resources may be available on other planets? What causes plaque to form in arteries? How is coal formed? At what rate do objects fall on the earth, compared to the moon? To find the answers to these or similar questions, the scientific method, which relies on inquiry, would be used.

In technology, the design process is used to develop solutions to problems that originate in the human-made world. What is the best way to manufacture a shoe? What design features are necessary when creating a newspaper advertisement? How do coal power plants generate electricity? What type of machine is needed to aid a blind person when identifying the type of soup in a given can? To create practical solutions to these technological problems, the design process is utilized. Discuss with students the scope of problems and design opportunities in technology and compare them with scientific problems. The learning experience, "What's Behind the Object," can be used to assist in distinguishing between science and technology.

Review the scientific method and problem-solving approaches with students so they understand the differences and similarities. Also, introduce the resources that are used in technology so they can be discussed in the various steps of the design process. Technological resources consist of tools, materials, resources, information, time, capital, and people. The activity, "Invention Sketch," will help students identify the resources in a product.

Present to the students a visual model to introduce the design process. Many technology education textbooks have a section about the design process. Then describe each of the steps by giving supporting examples and explanations. To actively engage students, consider creating about 25 cards with a particular aspect of the design process on each card. Cards might say, "Test the solution," "Make Sketches," "Build a Model," "Apply for a Patent," "Do Research," or "Write a Final Report." Give groups of 3 to 4 students a set of 25 cards or Post-it Notes™ and ask the students to sort them into a logical order. This helps them to realize that usually there is much planning that precedes creating and building something, which many students want to do first. Discuss with the class that although these steps seem to fall into order, the truth is that steps may be combined or even done out of order. Good designers are careful to document their work in an orderly fashion so they can come back to something previously done if problems arise. In technology, this documentation can be organized in a "Portfolio" or sometimes a "Tech-folio." Conclude this unit by allowing the students to experience the design process by solving a technological problem. Be sure students document their thinking and activities in a portfolio.

Since this may be the first design experience for students, the teacher may want to consider guiding students through the design process and providing the structure of the portfolio.

Suggested Learning Experiences

1. What's Behind the Object? – Groups of two to four students should work cooperatively to identify the scientific, technological, and mathematical connections to a common object.

   For instance, the teacher could hold up a pencil sharpener or other object and in three columns the groups would list the connections to it. "National Aeronautics and Space Administration (NASA), for Kids" is a website dedicated to providing web links that are educationally sound and focused on science and technology content. http://www.nasa.gov/kids.html

2. Invention Sketch – In Unit 1: Technological Innovation, students researched an invention and projected its use in 50 years. Now each student should create a sketch of that object and add colored shading as necessary. Notes should also be included on the sketches to further describe them. Most importantly, after the sketch is complete, students should identify how the seven resources in technology would be used to create the sketched object. These invention sketches should then be presented to the class. (TB-04, Page 39; TB-05, Page 53; TB-13, Page 59)

3. Design Problem – This learning experience can vary. Essentially, students are given a design problem and are asked to solve the problem using the resources available. Their work should be documented in a portfolio as described in Method 6, "Sharing Reporting," and "Recording Information" in *Teaching Technology: Middle School.* There are a variety of resources available that can be used to introduce the design problem. These are listed in the Resources section at the end of this guide. (TB-05, Chapter 4; TB-13, Chapter 4; TB-11, Chapter 7)

4. Model It – Based on their design sketches, students will use various tools and materials to create a model of their designs. Students should receive appropriate safety instruction prior to use of laboratory resources. Following its completion, students will present their models to the class. (TB-04, Chapter 3) "ScaleModel.net" is an Internet sited devoted to providing links to other sites that specialize in modeling. Sites can be searched for areas such as spacecraft, airplanes, military, ships, and architecture. This site also has a section devoted to modeling books, shops, and other special interest groups. http://scalemodel.net/

5. Design Brief – There are a variety of design briefs that can be used to introduce the design process. A design brief is a statement that is given so students are introduced to the initial problem and can begin developing ideas. The design brief also identifies any limitations and the context of the solutions. The materials listed in the

"Resources" section may be used to find design briefs for the students. Be sure that they contribute to attainment of the standards for this unit and are age-appropriate. (TB-02, Chapter 2)

These learning experiences were designed to acquaint students with the design process. The technology teacher has the option of selecting from comparable activities that:

- Align with technological literacy standards;
- Provide a cohesive structure to the entire curriculum;
- Connect in a variety of ways to technology content, other activities, and to other fields;
- Engage students actively as they design and construct a product or system during the unit.

Content Outline

I. Definitions

A. Technology – Human innovation in action
  1. Applies problem-solving strategies to solve real-world problems
  2. Focus is on the human-made world
  3. Uses the design process to develop solutions
  4. Knowledge and skills deal with creating, using, managing, and assessing technology

B. Science – The study of the natural world
  1. Applies methods of inquiry to answer questions
  2. Focus primarily on natural world
  3. Uses the scientific method to propose explanations
  4. Focus is on finding out "What is"

C. Examples of how science and technology work together for a common solution.
  1. Microscope – A technological device that is used for scientific experiments
  2. Magnetic Levitation Vehicle – A train (technology) that is suspended with superconductors (science)
  3. Sunspots – Science seeks to discover why sunspots occur and their potential impacts to the earth by using technological devices such as a telescope, satellites, and computer imaging.
  4. Hip Replacement – Polymers and metals are used to reconstruct a person's hip while the scientific aspects of the human body are studied.

D. Relationships between Technology and other subjects
  1. Social Studies and Technology
  2. Language Arts and Technology
  3. Art, Music, and Technology
  4. Mathematics and Technology

E. Scope of Technology in the Designed World
  1. Transportation – The movement of people and goods from one location to another
  2. Energy and Power – Providing the force needed to do work (energy) and determining the rate at which the work is being done (power)
  3. Informational – Using various technological devices to create, transmit, and interpret a message
  4. Medical – Maintaining and improving the physical well being of people
  5. Construction – Designing and making structures such as roads, bridges, houses, shopping malls, tunnels, and cranes
  6. Manufacturing – The production of goods
  7. Agricultural and Related Biotechnology – The manipulation and use of living organisms for various purposes, such as changing the form of food, improving health, or disposing of waste

II. Methods of Problem Solving

A. Design Process – Solve technological problems by developing ideas into solutions

B. Scientific Method – Propose explanations to questions in the natural world

C. Innovation Process – Create new and improved products

D. Troubleshooting/Debugging – Determine the reason a product or system does not function and correct it

III. Resources in Technology

A. People
  1. Team work
  2. Leadership

B. Information
  1. Finding information
  2. Accessing information
  3. Using information

C. Materials
  1. Natural resources
  2. Synthetic materials

D. Tools
  1. Safety requirements

Continued on page 24

Content Outline, continued

2. Power tools
3. Hand tools
4. Machines

E. Energy
1. Nonrenewable resources
2. Renewable resources

F. Capital

G. Time

IV. The Design Process
(There are many models to use for this process and this process may be adapted to meet specific needs. It is recommended that whichever model is chosen be used consistently in all courses.)

A. Get to Know the Problem
1. Conduct basic research related to the problem
2. Ask other people about their ideas
3. List requirements and limitations

B. Explore and Generate Ideas
1. Brainstorm by listing ideas
2. Make sketches with notes
3. Examine similar products

C. Select One Idea
1. Compare ideas against criteria and constraints
2. Ask other people about the ideas
3. Select the best one

D. Plan and Develop the Solution
1. Make a plan to build the idea
2. Create drawings from the sketches
3. Make a model – A three-dimensional representation of an idea, full size or scaled
4. Make a prototype - A full-size working product or system

E. Test and Evaluate
1. Ask others what they think of the solution
2. Test the solution to determine if it solves the problem
3. Analyze the physical properties of the object

F. Redesign if Necessary
1. Make changes based on the testing results
2. Use feedback from others to make changes

G. Present the Solution
1. Apply for a patent
2. Make an advertisement
3. Sell the product if applicable

Academic Connections

When students solve a particular design problem, it is important that they make connections to other academic areas. It would be impossible to list all of the possible connections since there are such a variety of design problems available. A general description is given for each content connection cited below.

Mathematics

1. Testing a Solution – When testing a solution, students will need to make calculations to help determine if the solution is correct and safe.

Science

1. Scientific Inquiry Method – This process will need to be reviewed with the students so they realize that it differs in focus and procedure from the design process.
   - http://www.nceas.ucsb.edu/nceas-web/kids/data/scimethod.html – Basic information about the Scientific Method
   - http://www.scientificmethod.com/booklet/contents.html – Examining the ingredients of the Scientific Method
2. Resources – Many of the resources listed have scientific connections. Specifically, when studying materials, students should realize that some are created naturally while humans make others.

Language Arts

1. Portfolio – As students develop their "Techfolio" or portfolio, they will need to use proper format, grammar, and spelling to document the work they have completed. In addition, identifying appropriate materials to use when researching a topic will need to be considered.
   - http://www.lacoe.edu/pdc/second/portfolio.html – Basic information about developing student, teacher, and electronic portfolios

Technological Theme Units

Overview

The thematic study of technology provides a deeper study of the technological content areas through a particular theme. These three strands provide a comprehensive "hands-on" and content-rich exploration of technology. By completing all of the units, students will have a wide variety of technological experiences along with a depth of coverage. Connections are made to mathematics, science, and other academic areas. It is important that this integration not be neglected, as it will fail to provide a comprehensive study of technology and its encompassing nature.

Unit 3: The Scope of Technology

In this unit, students explore the scope of technology. Learning experiences link to standards that identify content related to the designed world. These facets include medical technologies, agricultural and related biotechnologies, energy and power, information and communication, transportation, manufacturing, and construction.

Unit 4: Technological Integration

The content in this unit relates technology to an automobile accident. The integration of various aspects of technology is important for a connected understanding of this field and realizing that technology impacts common events. Students are faced with this general scenario and explore how technology impacts this common occurrence.

Unit 5: Explorations in Technology

Students at the middle school level possess a natural curiosity for discovering how things work. As these students move into the formal operational phase by Piaget, they want to explore the world around them through mental manipulations and abstract thinking. This unit utilizes this curiosity and changing thought processes by providing students an opportunity to examine how technological devices they will come in contact with actually function. Each section explores a different device to determine how it works and further examines the impacts and consequences it has had on our society as well as potential consequences and benefits for the future. The sections in this unit are organized around core concepts of technology. These concepts are studied in the final unit according to how they are applied.

These units do not need to be covered sequentially, although for a comprehensive understanding of technology, all the technological connections between the content areas should be studied. *Exploring Technology* is not a segmented set of activities, rather the connections develop as a section is concluded and another begins while a common theme runs throughout. Each unit is more completely described on the following pages.

Unit 3: Scope of Technology

Overview

In the first theme, students explore the scope of technology. Learning experiences relate to the standards that have been identified as part of the designed world. These facets include medical technologies, agricultural and related biotechnologies, energy and power, information and communication, transportation, manufacturing, and construction. To provide a sense of connection, the suggested learning experiences are framed around a general scenario dealing with the propagation, harvesting, transportation, and marketing of lettuce.

Enduring Results

***STL* Standards and Benchmarks**

1. Develop an understanding of the characteristics and scope of technology. (Standard #1)
   a. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (Benchmark F).
   b. The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. (Benchmark G).
   c. Corporations can often create demand for a product by bringing it onto the market and advertising it. (Benchmark I).
2. Develop an understanding of and be able to select and use agricultural and related biotechnologies. (Standard #15).
   a. Technological advances in agriculture directly affect the time and number of people required to produce food for a large population. (Benchmark F).
   b. Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment. (Benchmark I).
3. Develop an understanding of and be able to select and use energy and power technologies. (Standard #16).
   a. Energy is the capacity to do work. (Benchmark F).
   b. Power systems are used to drive and provide propulsion to other technological products and systems. (Benchmark I).
4. Develop an understanding of and be able to select and use information and communication technologies. (Standard #17).
   a. Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. (Benchmark H).
   b. The design of a message is influenced by such factors as intended audience, medium, purpose, and the nature of the message. (Benchmark J).
5. Develop an understanding of and be able to select and use transportation technologies. (Standard #18).
   a. Transporting people and goods involves a combination of individuals and vehicles. (Benchmark F).
   b. Governmental regulations often influence the design and operation of transportation systems. (Benchmark H).
6. Develop an understanding of and be able to select and use manufacturing technologies. (Standard #19).
   a. Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them. (Benchmark F).
   b. Marketing a product involves informing the public about it as well as assisting in its sales and distribution. (Benchmark K).
7. Develop an understanding of and be able to select and use construction technologies. (Standard #20).
   a. The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. (Benchmark F).
   b. Some structures are temporary, while others are permanent. (Benchmark H).
   c. Buildings generally contain a variety of subsystems. (Benchmark I).

Acceptable Evidence
1. Create a tri-fold poster that demonstrates a variety of agricultural processes
2. Maintain a design log throughout the unit
3. Design and build a greenhouse model that can be used to grow lettuce
4. Utilize a scale to create a drawing of the greenhouse
5. Automate at least one feature of the greenhouse
6. Design and produce a printed brochure
7. Design and build a hydroponic growing system
8. Participate in the manufacturing of a package
9. Work cooperatively to complete design activities

Suggested Learning Experiences

The learning experiences in each section are designed to accompany the "Overview" general scenario. Examples of appropriate learning experiences are given. The technology teacher has the option of selecting from comparable activities that:

- Align with technological literacy standards;
- Provide a cohesive structure to the entire curriculum;
- Connect in a variety of ways to technology content, other activities, and to other fields;
- Engage students actively as they design and construct a product or system during the unit.

Academic Connections

Mathematics

1. Calculate structural loads - In the construction unit, students should be given an opportunity to calculate loads. For example, students can measure the amount of force that is required to break a beam when various forces are applied. See "Understanding Forces" below for additional resource information.
2. Geometric shapes – During the construction unit, discuss various geometric shapes and how they relate to architecture. This is especially important as students begin to design and build their greenhouses.
   - http://www2.gvsu.edu/~bartera/ – Using geometric shapes in architecture
3. Scales as fractions – Students will be using scales as they construct their greenhouse.
   This should be used as an opportunity to review fractions and proportions with students.
   - http://www.iit.edu/~smile/ma8809.html – Learning ratios and proportions through scale drawings
   - http://www.mathleague.com/help/fractions/fractions.htm – A great review of fractions and their uses
4. Converting temperature – Students should understand the principles of mathematics related to converting Fahrenheit temperature to Celsius temperature. This can be incorporated into the energy and power unit.
5. Calculate travel time – In the transportation unit, students should use mathematical skills to calculate the amount of time it would take a truck to travel from Sacramento, California to Augusta, Maine.

Science

1. Understanding forces – Simple physics principles can be discussed as students learn about structural forces applied to different beams and structures.
   - http://www.technologysource.net/software/beam2.htm – Beam 2D is a software program used to calculate loads and forces (demo available for download).
2. Temperature/humidity – As students progress through the energy and power section, a discussion of temperature and humidity should be included so students realize the importance of monitoring and controlling these factors in the greenhouse and hydroponic systems.
   - http://www.cmhc-schl.gc.ca/publications/AboutYourHouse/ce01.html – Measuring humidity in your home
3. Food pyramid/ Nutrition – The informational section provides an excellent opportunity to review the food pyramid with students. Students should also write a brief report of specific nutritional benefits of lettuce.
   - http://www.nal.usda.gov:8001/py/pmap.htm – The food guide pyramid explanation and examples

4. Hydroponics – Scientific principles behind hydroponics should be discussed as students complete the agricultural unit section. These principles include mixing chemicals, measuring attributes of water, monitoring plant growth, and plant root systems. See TB-07.
   - http://www.ozemail.com.au/~accent/fivesys/fsys0001.htm – Hydroponics, the basics. Follow each section carefully.
   - http://archimedes.galilei.com/raiar/histhydr.html – The history of hydroponics
5. Chemicals used for plant growth – Students should understand how some chemicals are used in hydroponics to stimulate plant growth. They can experiment by adding differing quantities of particular chemicals, then observing the results.
   - http://www.atlantic.net/~elifritz/hydroponics.htm – Information about the design and construction of hydroponics systems and the proper chemicals to use

Social Sciences

1. Related careers – Students should be presented with a list of careers related to hydroponics. Each career should be discussed. Alternatively, students could conduct research of careers in this field.
   - http://www.cas.psu.edu/docs/CASHOME/AGCAREERS.HTML – Listing of agricultural-related careers from Penn State University
   - http://www.fb.com/today/class/careers.htm – Careers listed by the American Farm Bureau Federation
2. Community greenhouses – Students should find at least three greenhouses in the community and report on what plants are being grown in each. Also, students could determine where these plants will be sold and how they will be transported.
3. Data Collection – During the informational unit, students should conduct research to determine the amount of vegetables eaten by children their age. Students should be able to locate a national survey on the subject. Alternatively, students could conduct original research using students at their school as respondents.
4. Geography – United States geography is central to the transportation unit. Use this as an opportunity to review the location of states and also topography such as what mountain ranges must be passed over and what major rivers will be crossed as the lettuce is transported from California to Maine.
   - http://www.fedex.com/us/ - Federal Express Home page
5. Map reading –During the transportation unit, students should be given a map of the United States and a list of questions that will help them improve their map-reading skills.
   Examples of questions include distances from one major city to another, what interstate would be traveled from one major city to another, and what alternate route could be traveled from one major city to another.
   - http://www.mapquest.com/ - This site provides travel distances, estimated travel time, and maps between cities in the United States

Language Arts

1. Article Summary – Students should read an article related to hydroponics and briefly present it to the class.
2. Word Origin - Students should understand the origin of the word hydroponics. W. F. Gerike coined the word *hydroponics* at the University of California in the 1930s. The word was derived from two Greek words. *Hydro* means water and *ponic* means labor. Students could brainstorm other words they know with the prefix “hydro.”
   - http://www.m-w.com/info/vocab/putlog.htm – Merriam-Webster’s Vocabulary Builder offers a variety of common root words
3. Spelling and Grammar – Students should check each other’s print media for spelling and grammatical errors. The teacher should do a similar check only after editing has been completed.
4. Descriptive Wording – As students add information and drawings to their “Designed World” log book, they should make sure that descriptive words are being used in place of ones that are more general.

General Scenario:
You need to buy lettuce, or some other fruit or vegetable, for your family at the grocery store. Some of the lettuce looks fresher, and there is a large variety to choose from. How does the lettuce get to the grocery store? How does it stay fresh for so long? Can it be grown in a cold climate? What are the health benefits of lettuce and other vegetables? Each of these, and many more, questions will provide the focus as students study each of the seven facets of the designed world.

Student Preparation

Before beginning this theme, each student could create a "Designed World" log. In it they will record short entries about technology they see in their daily lives. The goal is for students to realize the breadth and depth of technology in their world. Method 6: Sharing, Reporting, and Recording Information, in *Teaching Technology: Middle School*, provides guidance for this activity.

Overview of Unit Sections

Section 3-A, Construction: Where is lettuce grown? Greenhouses are used to begin the germination process and sometimes for the entire growth cycle. How do greenhouses work to assist in growing plants? This is the main question addressed in this unit. Students will study the common characteristics of greenhouses and find out about basic automation techniques for keeping them at a precise temperature and humidity. Students will construct a small prototype of a greenhouse and begin the germination of the lettuce plants.

Section 3-B, Energy and Power: How are greenhouses kept warm? To make their greenhouse efficient students need to be able to monitor and control the inside temperature and humidity. To accomplish this, students will need to have a basic understanding of automation and how it applies to greenhouse design. Many geographic connections are made in this unit as students study the topography of the United States.

Section 3-C, Informational: Why should people eat vegetables? Lettuce has some tremendous health benefits that should be conveyed to as many people as possible. To accomplish this, there are many informational avenues that can be utilized, especially ones that are visual in nature. Students will explore each of these and then decide which to use for a particular target audience. Some may be electronic in nature (on a kiosk or the Internet) while others use print media (billboards, brochures, newspaper ads, or flyers). Regardless of the medium being used, all work should begin with layout sketches and conclude with a computer-generated product. Included in this informational piece should be drawings of a proposed greenhouse, the health benefits of particular vegetables, how vegetables are grown, and additional sources of reference material.

Section 3-D, Agriculture: How are lettuce and other vegetables grown? Students will create a hydroponic lettuce system and its particular subsystems. This understanding of systems in agriculture is also related to the growing seasons and how crops are planted, fertilized, and harvested. They will also gain a basic understanding of chemicals and their role in plant growth. Once their seeds have properly germinated, students will transfer them to a hydroponic growing system so the lettuce can reach full maturity.

Section 3-E, Transportation: How does lettuce get from the place it is grown to your grocery store? Transporting fruits and vegetables requires a complex set of intermodal vehicles. To coordinate this effort there has to be effective communication, precise timing, and reliable vehicles that are equipped with proper refrigeration equipment. In this unit, students will be working as a class to develop the necessary transportation vehicles to simulate transporting lettuce from California to Maine. Many geographic connections are made in this unit as students design an intermodal transportation system.

Section 3-F, Manufacturing: Fresh fruit and vegetables must be packaged correctly before they are shipped. The package must not only protect the food, but also not allow it to ripen too quickly, and display appropriate content information. Each student will create a package for lettuce and determine its usefulness. What are some of the advancements in "breathable" packages or ones that keep their contents cool for an extended period of time?

Section 3-A: Construction

Overview

Where is lettuce grown? Greenhouses are used to begin the germination process and sometimes for the entire growth cycle. How do greenhouses work to assist in growing plants? This is the main question addressed in this unit. Students will study the common characteristics of greenhouses and relate basic automation techniques for keeping them at a precise temperature and humidity. Students will construct a small prototype of a greenhouse and begin the germination of the lettuce plants.

Narrative

Discuss the process that agricultural products follow when growing. This process can be adapted to a problem-solving model referenced in the "Technological Design" unit at the beginning of the course. Most technology education textbooks introduce this process, although many of them do not have an agricultural component. The activity "Agricultural Processes" will help students understand the real-world connection to the forthcoming activities. It is important to note that this information is covered in the construction unit, as students will be using this information to design and construct a model greenhouse.

In the world of construction, many areas could be explored. In this unit, students will be studying the structural features of a greenhouse that can be used to grow plants. In their logbook, students should complete the "Hometown Structures" activity.

Introduce the concept of how a greenhouse works by reviewing the scientific principles behind the greenhouse effect. Since there are many environmental issues related to this, students should study them even if they are not in a high-pollution area where the greenhouse effect can be readily seen. By working in groups of three or four, students should be involved in some research of greenhouses. They should individually record their findings in their logbooks.
A variety of Internet sites are listed that contain information about greenhouse design.

Based on the information obtained by the students when researching greenhouses, they should, as a group, begin making preliminary sketches of their model greenhouse. This should be followed by the "Designing a Beam" or "Buildings of the Future?" activity, which allows students to test the various types of trusses and the forces applied to them. The loads placed on a greenhouse will vary between locations in which they are constructed. Regardless of where in the country a greenhouse is built, students should have an understanding of loads on a structure.

Structural forces should be introduced immediately after the section on loads and structural systems. When loads fail, students should understand why they failed and the types of forces that were occurring when this happened. At this point students could briefly study the history of structural systems and identify where they see these construction techniques today.

Before any drawings for the greenhouse can be created, students need to have a basic understanding of how a scale can be used. It will be important to review basic mathematical principles related to proportions and fractions. The activity "Line Length" will help students have a basic understanding of how to draw scaled lines.

Students should already have a basic understanding of how to create sketches. Usually drawings have more detail and precision than simple sketches require. These drawings include multiview, isometric, oblique, and perspective. The "Greenhouse Plans" activity will introduce students to these types of drawings.

Finally, students should obtain approval for a final drawing of their model greenhouse. Once approved, they can begin constructing a model of their greenhouse. The models should not exceed four square feet.

Content Outline

I. Agricultural Processes
- A. Propagating – Spreading and planting the seeds
- B. Growing – Plants grow to full maturity
- C. Maintaining – Monitoring plants so they are healthy and free of insects or disease
- D. Harvesting – Taking the plant
- E. Adapting – Growing plants in atypical soil-like conditions
- F. Treating – Protecting the plants from disease
- G. Converting – Moving plants from seedlings to permanent location
- H. Processing – Transforming the plant from harvested crop to usable product.

II. Types of Construction
- A. Infrastructure – Roads, bridges, sidewalks, tunnels
- B. Residential – Homes, garages, decks
- C. Commercial – Buildings, banks, restaurants, parking garages, airports, stores
- D. Industrial – Factories, shipyards, oil rigs, farms

III. Greenhouse Properties
- A. The “Greenhouse Effect” on the earth
- B. Greenhouse design
- C. Venting a greenhouse
- D. Monitoring a greenhouse
  1. Plant growth
  2. Conditions
- E. Constructing a greenhouse

IV. Structural Design
- A. Loads
  1. Dead Loads – Entire weight of the structure
  2. Live Loads – Applied weight by additional forces
  3. Dynamic Loads – Rapidly-changing loads (earthquake, sonic boom)
  4. Wind Loads – Forces caused by gusting winds
- B. Forces
  1. Compression – Object pushed together
  2. Tension – Object is pulled apart
  3. Shear – Sliding force
  4. Torsion – Object twisted
- C. Structural Systems
  1. Substructure
  2. Structure
  3. Superstructure

V. Drawing to Scale
- A. Architect’s Scale – Organized around the fractional inch (1/16)
- B. Engineer’s Scale – Organized around the decimal inch (.063)
- C. Metric – Organized around the meter unit

VI. Types of Drawings
- A. Perspective – All lines converge at 1, 2, or 3 points
- B. Multiview – Top, side, and front usually shown
- C. Pictorial – View of finished object or structure-isometric, oblique

Suggested Learning Experiences

Agricultural Processes – Each student brings in one vegetable, fruit, or grain product. Group students (not to exceed four) according to the item they brought to class. In each group, students should identify the processes used in agriculture to grow their particular item. The website, Eat-5-A-Day (http://www.5aday.com/), is helpful for finding important information about various fruits, vegetables, and grains. These materials should be organized according to the agricultural process and presented on a tri-fold poster. Finally, each student should write a short entry into their “Designed World” log about the similarities and differences of how these items are grown.

Hometown Structures – As students come to and from school they observe various structures. Have students sketch three different types of structures for each of the four construction types in their log, accompanied by a short description of the structure’s purpose. If possible, one of these should be a greenhouse.

Charley’s Greenhouse – This site offers material about choosing and building your own greenhouse. Information is given about design, venting, monitoring, and construction techniques.
http://www.charleysgreenhouse.com/a_greenhouses/grn-house_index.html

Energy-Efficient Greenhouse Design – These sites contain information about analysis of greenhouse design options, design of energy-efficient facilities, monitoring of energy use and growing conditions. Technical information is given about glazing, covers, orientation, geometry, ventilation fans, and heating systems. http://www.enermodal.com/greenhouse_design.html; http://www.yale.edu/ynhti/curriculum/units/1983/1/83.01.13.x.html#j

Designing a Beam – Students utilize an 8 ½" x 14" piece of card stock, white glue, and scissors to construct a beam that can span 8". This beam will then be tested for various load capabilities. (RB-04, Page 1; TB-10, Chapter 8)

Buildings of the Future? – In this activity students have to design a tensile structure that may be very similar to a greenhouse, although the written activity is for a futuristic space colony. (TB-01, Page 259)

Structural Forces Presentation – Students create a group presentation that demonstrates the differences between structural forces. Each force should be illustrated and used as a visual aid during the presentation. (TB-03, Chapter 24)

Building Truss Structures – Students build several different truss structures and test their support characteristics. (TB-10, Page 83)

Architectural History – This chapter describes various types of structural systems and their characteristics. (TB-08, Chapter 15)

Understanding Scale – Begin by reviewing basic mathematics principles related to fractions. Some students will have difficulty measuring if they do not understand fractions. Have each student draw a line that is one foot long. Show the students how to use the 1" = 1' scale to draw a line that is 1" long, but represents a foot. Follow the same procedure for other scales and units of measurement.

Greenhouse Plans – Students should use the sketches they created to make more detailed drawings of their greenhouse. Begin with multiview drawings. Students should draw their greenhouse idea, showing a front, side, and top view. For the review component, pin up the drawings from the class around the room. Assign each student a different drawing and have him or her review it and write comments on it. Then, after about three minutes, students should rotate one place to the left and do the same thing. Give each student the opportunity to review about five different drawings. Students should then revise their ideas and create subsequent isometric, oblique, or perspective drawings (if the student has this background). (TB-04, Chapter 2; TB-12, Chapter 2)

Section 3-B: Energy and Power

Overview

How are greenhouses kept warm? To make their greenhouse efficient, students need to be able to monitor and control the inside temperature and humidity. To accomplish this, students will need to have a basic understanding of automation and how it applies to greenhouse design.

Narrative

The concept of automation versus mechanization may be new to most of the students. Use the greenhouse example to show how a mechanized system would require a human to constantly monitor the temperature and humidity. If greenhouse conditions were to change, humans would be responsible for ensuring that these conditions were maintained at the appropriate levels. On the other hand, an automated greenhouse would monitor temperature and humidity, but if changes needed to occur, they would occur automatically. This is somewhat like a thermostat in a house. The "Technology and Mechanisms" series of activities or the "Automation" activity will help students understand the basics of automation.

Students could construct a commercial greenhouse model. For example, one model has a temperature sensor that opens a door and turns on a fan if it gets too hot. Items can be added to make it more complex and realistic. It would then be possible for students to install a thermometer and humidity indicator in their greenhouse. Discuss with the class the positive and negative aspects of an automated industry. Students should write their reactions in their logbooks.

Students should now plant their lettuce or other vegetable seeds so the germination process can begin. Monitor the seeds on a daily basis and be sure the soil composition is correct and there is plenty of light.

Content Outline

I. **Mechanization** – Humans responsible for monitoring and acting as needed

II. **Automation** – Computer or other program monitors and makes changes as needed
- A. Sensing – Measures the performance or property of an object
- B. Action – Provides energy to complete the task
- C. Control – Regulates action elements
- D. Decision – An automatic change is made due to conditions
- E. Program – Produces process and command information

III. **Benefits of Automation**
- A. More precise work
- B. Robots can do dangerous work
- C. Constant monitoring not required

IV. **Consequences of Automation**
- A. Jobs lost to machines
- B. Failure can mean disaster

Suggested Learning Experiences

Technology and Mechanisms – This series of activities allows students to explore a number of simple mechanisms that are used to produce power, control, and motion for technological devices. (CITE, #P153)

Automation – These activities allow students to explore automation by constructing and testing robots and by constructing automated tooling and other devices. (CITE, #P151)

Sound, Sensors, & Logic – Students examine the impact of sensors to detect smoke and heat as it relates to the technological systems model. The activity can be adapted for students to do sensing work in a greenhouse. (RB-04, Page 23)

Section 3-C: Informational

Overview

Why should people eat vegetables? Lettuce and other vegetables have some tremendous health benefits that should be conveyed to as many people as possible. To accomplish this, there are many informational avenues that can be utilized, especially ones that are visual in nature. Students will explore each of these and then decide which to use for a particular target audience. Some may be electronic in nature (on a kiosk or the Internet) while others use print media (billboards, brochures, newspaper ads, or flyers). Regardless of the medium being used, all work should begin with layout sketches and conclude with a media-generated product. Included in this informational piece should be drawings of a proposed greenhouse, the health benefits of particular vegetables, how vegetables are grown, and sources of reference material.

Narrative

In this unit, students will be studying ways to effectively communicate information such as the importance of eating vegetables, fruits, and grains. This will be accomplished by having them design a visual media product. Begin the unit by having students record the types of advertising they are confronted with in a typical day. This may include the Internet, print, billboards, and bumper stickers. Students should be working in groups of four. Before any message can be designed, the target audience must be identified. The "Vegetable Survey" can be used to help the students identify the audience for their visual message.

Once the audience has been identified, students can proceed with making sketches of their ideas. The groups should not limit themselves to just one type of print media at this time. A final sketch should be submitted after preliminary ideas have been narrowed down. Other faculty members or students should review this final sketch to obtain a variety of responses. Finally, the visual message should be completed, produced, and delivered to the specified audience.

Content Outline

I. Designing a Message
- A. Audience Profile
- B. Format (Size and Shape)
- C. Gathering the Content (Text and Illustrations)
- D. Production Cost Estimate

II. Preparing to Produce the Message
- A. Create Initial Sketches
- B. Finalize Designs
- C. Verify Accuracy of the Message

III. Producing the Message
- A. Make the Layout
- B. Select Method of Printing (Electrostatic, Electronic, Screen Printing, Offset)

IV. Delivering the Message
- A. Distribution
- B. Evaluating the Message
- C. Planning for the Future

Suggested Learning Experiences

Vegetable Survey –Students should each create a simple survey that asks respondents to identify various vegetables, fruits, or grains they enjoy eating and includes demographic information. The intent of the survey is to identify which of those items people enjoy, as well as the respondents' ages and gender. This survey can be given to parents, neighbors, friends, faculty, and other students. If possible, students should seek to have respondents of varying ages complete the survey including elderly adults. It is important that as many people as possible complete the survey to give a wide range of responses. Students should create a bar graph that displays their findings.

Graphic Engineering – This activity has students creating a pop-up brochure. It can be adapted so students should have to create a visual product that describes the benefits of eating various vegetables. (RB-04, Page 27)

Section 3-D: Agriculture

Overview

How are lettuce and other vegetables grown? An understanding of technological systems in agriculture is related to the growing seasons and how crops are planted, fertilized, and harvested. Students gain a basic understanding of chemicals and their role in plant growth. In this section, students will create a hydroponics lettuce system to explore plant growth using technology. Once the seeds have germinated, the students will transfer them to a hydroponics system to find out how the lettuce reaches full maturity.

Narrative

When the lettuce seeds that were planted in the model greenhouses (see Section A) have sprouted, they are ready to be placed in a hydroponic environment. Begin this unit by discussing with students the basic aspects of any growing system. This can easily be related to growing a houseplant or garden.

Discuss with students the various types of hydroponic systems. There are three different types of systems. The gravity flow system allows nutrients to move from one bucket through the aggregate and drain into another bucket. The sub-irrigation system uses one tank that pumps the nutrient fluid into the aggregate and is controlled by a timer. This type of system relates closely with a greenhouse construction where sensors can be used to monitor humidity and temperature. The final hydroponic system uses a wick system. The nutrient fluid is below the plant and the wick pulls the solution into the aggregate.

Suggested Learning Experiences

Designing a System: Preparing an Environment – In this activity students build a hydroponic growing system. This section also contains useful information about the history of hydroponics and leads the student through how to build a hydroponic system. (TB-07, Technology Investigation T4)

Testing a Hydroponics System – In this activity students are involved in testing the growth of the lettuce and making suggestions for improving the existing system. Students can also compare their system to others to find the advantages and disadvantages of each.

Finally, students must harvest the lettuce. As explained in the activity, students should carefully measure the characteristics of the lettuce and compare them. This will help them determine which systems worked more efficiently and why this occurred. (TB-07, Technology Investigation T5 to T7)

Section 3-E: Transportation

Overview

How does lettuce get from the place it is grown to your grocery store? Transporting fruits and vegetables requires a complex set of intermodal vehicles. To coordinate this effort there has to be effective communication, precise timing, and reliable vehicles that are equipped with proper refrigeration equipment. In this section, students will be working as a class to develop the necessary transportation vehicles to simulate transporting lettuce from California to Maine. Many geographic connections are made in this unit as students design an intermodal transportation system.

Narrative

As the lettuce grows in the hydroponic systems, students will be developing an intermodal transportation system. It will simulate the transportation of lettuce from one coast to the other. Before giving the students the information they need about the five keys to intermodal transportation, have them complete the brainstorming activity described in "Making Movers." After they have finished this activity, describe the five items listed as keys to intermodal transportation.

Give students the scenario described in "Coast-to-Coast Transportation." They can use an Internet site such as http://www.mapquest.com/ for geographical and travel information.

Content Outline

I. **Keys to Intermodal Transportation**
   - A. Communication – Between sender and receiver
   - B. Time & Scheduling – Making sure goods are "Just-in-time"
   - C. Safety & Security – Goods are sent with quality in mind
   - D. Pathways to follow
     1. Land
     2. Space
     3. Air
     4. Water
   - E. Cost

II. **Planning Intermodal Transportation**
   - A. Determine destination and origination points
   - B. Identify desired product condition before and after shipping
   - C. Brainstorm for ideas
   - D. Examine possible pathways
   - E. Consider cost
   - F. Plan final route
   - G. Run simulation in varying conditions
   - H. Evaluate plan and make changes as necessary

Suggested Learning Experiences

Making Movers – What is required for a product to travel from one coast of the U.S. to the other? Have students work in groups of three and brainstorm for the general categories of transportation. Students should focus on human factors rather than specific types of machines. They may come up with a long list, which should then be summarized and categorized into a few groups.

Coast-to-Coast Transportation – Students are to design and develop a plan that would transport their lettuce from California to Maine in the least amount of time and at the lowest cost. They must include three different forms of transportation. A brief outline of the procedure is given below.

- Show a map of the U.S. and identify California and Maine. If possible, use a computerized atlas or mapping program. This is also a good time to review scales as they relate to reading maps.
- Determine the distance from each city in the appropriate state.

- Discuss how to plan for intermodal transportation.
- Have students develop a plan based on the eight steps identified in the content outline column. This plan must account for the fact that lettuce must remain cool, move quickly, and be transported at reasonable cost. If possible, use an atlas or map program on the Internet to assist in this planning.
- Finally, students should develop and present a map that shows how the lettuce will be transported.

Section 3-F: Manufacturing

Overview

How is lettuce kept fresh and undamaged at it travels hundreds of miles? Any fruit or vegetable has to be packaged correctly before it is shipped. The package must not only protect the food, but also not allow it to ripen too quickly or too slowly and display appropriate content information. Each student will create this package and determine its usefulness. What are some of the advancements in "breathable" packages or ones that are required to stay cool for an extended period of time?

Narrative

After 60 days, the hydroponic lettuce should be grown. If it is not, the teacher could purchase some leaf lettuce for this activity until the hydroponic lettuce is finished. This unit gives students an overview of manufacturing before they begin forming an assembly line. Invite a guest speaker who works in a manufacturing company or take a field trip to a manufacturing plant. Students need to have a better understanding of contemporary manufacturing. After discussing the primary and secondary aspects of manufacturing, have students complete the "De-Manufacturing" activity. At the conclusion of the activity, discuss the precision and planning that is involved in manufacturing.

This will lead very nicely into a discussion of the four manufacturing systems. Using the products from the "De-Manufacturing" activity, students should record in their logbooks how each each of these systems could have been used to create their product.

To simulate a real manufacturing company, the class will be producing a package for their lettuce. Each student will make a model of his/her idea and present it to the class. The class should decide on the best three ideas and then work as smaller teams to further develop the product. Finally, a final product is selected and the class should be organized into a manufacturing company. The "Packaging: More Than Just a Box" and "Can You Handle It?" activities will assist as students begin the manufacturing process. There are a variety of textbooks that describe manufacturing: see TB-01, Chapter 8; TB-12, Chapter 12; TB-02, Chapters 8 to 14.

Content Outline

I. Manufacturing Processes
- A. Primary – Changing raw materials into industrial materials
  1. Mechanical
  2. Thermal
  3. Chemical
- B. Secondary – Changing industrial materials into finished products
  1. Casting and Molding
  2. Forming
  3. Separating
  4. Conditioning
  5. Assembling
  6. Finishing

II. Manufacturing Systems
- A. Custom – Product made individually
- B. Intermittent/Batch – Products made in specified small quantities
- C. Continuous – Parts are moved down an assembly line and attached to the product
- D. Flexible – Low-cost computer controlled intermittent production

III. Developing a Manufacturing System
- A. Select Operations – Jobs listed
- B. Sequence Operations – Jobs organized on a flow process chart
- C. Select Equipment – Tools and machines identified for each job
- D. Arrange Equipment – Room arranged according to the flow process chart
- E. Design tooling – Jigs and fixtures built
- F. Control Quality – Products are checked for defects
- G. Test the System – Run a few pieces through to work out the flaws

Suggested Learning Experiences

De-Manufacturing – The concept behind this activity is for students to take apart a simple product to determine how it was manufactured. Have each student either bring in a product that they have at home that does not need to be returned, or have some available in the classroom. Working in pairs, students should very methodically remove individual pieces from the product and record three details about it: name, function, and location. This information should be recorded in their logbooks. Then they should arrange the pieces to show how the product may have been manufactured and include a set of instructions. This may look somewhat like an assembly drawing, except with the actual parts. Then the groups will rotate to a different product and use the instructions to attempt to assemble the product as per the instructions.

Packaging: More Than Just a Box – This activity reinforces the idea that a good package has important marketing and design components. In addition, students recognize that many packages can be made of a variety of materials. (RB-04, Page 3)

Can You Handle It? – In this activity students have to design and construct a conveyor system that can transport their package from one station to another. This conveyor belt should also have some basic automation features to make the process more reliable. (TB-01; Page 178)

Unit 4: Technological Integration

This theme is designed to show students the interconnectedness between technology and other fields of study. Students will be using a scenario that commonly occurs, a traffic accident, to develop this understanding. As they progress through each of the four separate units within this theme, hands-on design activities are suggested. Teachers may choose to deliver the activities as they are presented or adapt them as needed. It is important, though, that the intention of the activities not be lost if they are adapted. In addition, a variety of websites is provided for quick reference.

Enduring Results

***STL* Standards and Benchmarks**

1. Develop an understanding of the characteristics and scope of technology. (Standard #1).
   a. The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. (Benchmark G).
2. Develop an understanding of the relationships among technologies and the connections between technology and other fields of study. (Standard #3).
   a. Technological systems often interact with one another. (Benchmark D).
   b. A product, system, or environment developed for one setting may be applied to another setting. (Benchmark E).
   c. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. (Benchmark F).
3. Develop an understanding of cultural, social, economic, and political effects of technology. (Standard #4).
   a. The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use. (Benchmark D).
   b. Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. (Benchmark E).
   c. The development and use of technology poses ethical issues. (Benchmark F).
   d. Economic, political, and cultural issues are influenced by the development and use of technology. (Benchmark G).
4. Develop an understanding of and be able to select and use medical technologies. (Standard #14).
   a. Advances and innovations in medical technologies are used to improve healthcare. (Benchmark G).
5. Develop an understanding of and be able to select and use information and communication technologies. (Standard #17).
   a. Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. (Benchmark H).
6. Develop an understanding of and be able to select and use transportation technologies. (Standard #18).
   a. Transporting people and goods involves a combination of individuals and vehicles. (Benchmark F).
7. Develop an understanding of and be able to select and use construction technologies. (Standard #20).
   a. The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. (Benchmark F).
   b. Some structures are temporary while others are permanent. (Benchmark H).
   c. Buildings generally contain a variety of subsystems. (Benchmark I).

Acceptable Evidence

1. Design and build a model of a structure that has a direct impact on the livelihood of individuals.
2. Illustrate how various transportation systems have positive and negative impacts on society, individuals, and the environment. In addition, recognize that transportation devices are designed around a variety of criteria for a specific function.
3. Explain how informational messages are cycled from transmission to reception and back again.
4. Design and build a medical apparatus for someone with a particular disability or limitation.
5. Describe how various technologies work together to accomplish a set goal.

Suggested Learning Experiences

The learning experiences in each section are designed to accompany the "Overview" general scenario. Examples of appropriate learning experiences are given. The technology teacher has the option of selecting from comparable activities that:

- Align with technological literacy standards;
- Provide a cohesive structure to the entire curriculum;
- Connect in a variety of ways to technology content, other activities, and to other fields;
- Engage students actively as they design and construct a product or system during the unit.

General Scenario:
A serious car accident in which two persons are injured has occurred. One of the passengers has an arm that is obviously broken and bleeding. The driver is more seriously injured and may need to be transported to another hospital by a helicopter. As someone stays with the victim, students must phone 911 for help. They will go through the process of phoning for help, transporting the injured party to the hospital by ambulance and the other individual by helicopter. To further their understanding of technology, students will explore how the facets of the designed world impact a somewhat common occurrence such as a car accident. They will realize that technology extends far beyond the misconception "technology is about computers" to one that encompasses technology as a broad field that impacts individuals, societies, and the environment.

Student Preparation

Students could gather information concerning local emergency services. They may interview emergency medical technicians, firefighters, and police officers. Students should think about the role of technology in handling emergency situations and how technology impacts people's lives.

Overview of Unit Sections

Section 4-A, Information and Communication: To contact the hospital, an onlooker uses a cellular telephone. Students will understand that communication includes both graphic and electronic transmissions and that all messages follow a systematic pattern. For a realistic example, the common 911 system will be studied. For instance, how is information simultaneously transmitted to the hospital, ambulance service, police, and other key agencies? This requires a sophisticated communication system that needs to operate flawlessly. In the next section, the injured persons are transported to a hospital by ambulance or helicopter.

Section 4-B, Transportation: The injured passengers will need to be transported by an ambulance or helicopter. Some ambulances (like the ones in this scenario) and helicopters use a vehicle locator system so the central communications network can track the vehicles. This technology allows hospitals to quickly predict the arrival time and reroute the vehicle if there is congested traffic on their proposed route. What kind of equipment is required in an ambulance or medical helicopter? As the characteristics of transportation technology are explored, students will recognize that all vehicles utilize similar systems to complete their route. In addition, students will design and construct a vehicle that replicates an ambulance of the future.

Section 4-C, Construction: One of the injured passengers will require use of a wheelchair upon returning to his home. In order for him to enter the home, a ramp needs to be constructed to improve safe home accessibility. Since the ramp may be needed temporarily, it should be easy to adapt in other locations and transportable. Students will design and build a model of an access ramp for a building in their community or a home.

Section 4-D, Medical: In the final unit, the individual with the severely broken arm must have it amputated. Since this person will need to use it in conjunction with his/her other arm, an artificial limb needs to be designed. For the time being, the limb should be able to do common tasks (picking up a can of soup, turning on a light switch, and picking up a coffee mug). Students will need to investigate how artificial limbs operate and then design and construct a basic model of one.

Academic Connections

Mathematics

1. Cost Comparisons – Calculating and comparing the costs of a variety of advertising means. Students should average the yearly costs for the comparisons.
2. Bill Calculations – Students should be able to look at a cellular phone bill and determine how the costs have been calculated. This would include taxes, surcharges, and the various per/minute rates.
3. Vehicle Calculations – Students will be required to use formulas to calculate the velocity and speed of their vehicle. In addition, they will need to convert some of the units of measurement in order to make the measurements more manageable.
   - http://library.thinkquest.org/16600/beginner/kinematics.shtml – An easy-to-understand review of basic physics principles
4. Ramp Angles – Students must have a basic understanding of geometric shapes and their properties. Review the principles for measuring and the various kinds of angles. Provide a variety of angles that students can measure with a protractor.
   - http://www.dragnet.org/rampman/rampman.htm – The Home Ramp Project describes the basics of design ing and building a modular wheelchair ramp.
5. Scales – Since students will be constructing a model of their ramp, they should understand how to use a scale to make the ramp the correct size and angle.
   - http://www.iit.edu/~smile/ma8809.html – Learning ratios and proportions through scale drawings
6. Mean, Median, and Mode – Using the anthropometric data, students will calculate the mean, median, and mode of each of the human measurements. If possible, the teacher can then show the class how a bell curve can be used to describe the entire population.
   - http://www.statsoft.com/textbook/stathome.html – StatsSoft publishes an online statistical textbook that can be used to review basic statistics.
7. Proportions – Using the anthropometric data, students will calculate various proportions between various body parts. For instance, what is the relationship between a pointer finger and a thumb or other finger? This data will be used to help students design their prosthetic arm.
   - http://ergo.human.cornell.edu/DEA325notes/anthrodesign.html – Information about anthropometrics and design

Science

1. Radio Waves – Discuss how sound and radio waves are transmitted over hundreds of miles and then compare this with the telecommunication system used in a cellular telephone.
   - http://www.smgaels.org/physics/radio_1.htm – An overview of radio waves including their discovery, dangers, uses, and interesting information
2. Units of Measurement – When testing the electric vehicle, students should measure the time, distance, velocity, and speed. This will require an understanding of force and motion.
3. Soil Make-up – Since a full-size ramp would need to be set on a firm foundation, students need to understand that there are differences in soil composition which would influence the type of foundation that is made.
   - http://www.ars.org/experts/composition.html – Soil composition: The Root of the Matter
4. Human Body Size – Students will be measuring various body parts. If possible, show a chart that indicates how these sizes change as someone ages.
   - http://ergo.human.cornell.edu/DEA325notes/anthrodesign.html – Information about anthropometrics and design

Social Sciences

1. Cellular Impacts – Students should study how cellular telephones have impacted our society. This can include studying what professions have been changed because of cell phones, the number of people in different social groups who own cellular phones, how communication between families has been made easier, and the impact that the cellular telephone industry has had on society.
   - http://www.wow-com.com/ - This site contains statistics and surveys, laws, 911 statistics, and news about cell phones.
2. Impacts of Transportation – By reading the newspapers, students will realize the significant impacts that transportation has had on the entire world.
3. As an optional activity, students could trace the history of a transportation vehicle. The "History of the Helicopter" Internet site provides an excellent account for this activity.
4. Students could consider statistics related to traffic accidents such as how many involve younger drivers.
5. ADA – Students should understand the basic tenets of the Americans with Disabilities Act (ADA) and how this impacts building and sidewalk construction.
6. Disabled historical figures – Students will consider various historical figures who overcame a physical disability.
   - http://laran.waisman.wisc.edu/fv/www/general/famous.html – Information about famous people with disabilities
7. Disabled statistics – Students will review statistics related to the number of disabled individuals in the U. S. and specifically those with prosthetics.
   - http://www.census.gov/hhes/www/disable.html - Census Bureau data on characteristics of people with disabilities
   - http://www.independentliving.org/DAA/DAAKit1.html - Disability Awareness in Action Resource Kit

Language Arts

1. Forensics – Students need to have a basic understanding of how to deliver an audio and/or visual or multimedia presentation.
2. Story Development – Students design a storyboard or script for their presentation that follows a typical paragraph outline (Introduction, Body, and Conclusion).
3. Complaint Letter – Students write a complaint letter to a local government about a real or fictitious building that does not meet the regulations set forth in the ADA. Students should be instructed in the format of a business letter.
4. Autobiographical sketch – Have students read an autobiographical sketch of a person who was disabled in an accident. Examples include Christopher Reeve, Joni Erikson-Tada, and Dave Dravecky.
   - http://laran.waisman.wisc.edu/fv/www/general/famous.html – Information about famous people with disabilities

Section 4-A: Information and Communication

Overview

To contact the hospital, an onlooker uses a cellular telephone. Students will understand that communication includes both graphic and electronic transmissions and that all messages follow a systematic pattern. For a more realistic viewpoint, the complex 911 system will be studied. For instance, how is information simultaneously transmitted to the hospital, ambulance service, police, and other key agencies? This requires a sophisticated communication system that needs to operate flawlessly. In the next section, the injured passengers are transported to a hospital by ambulance or helicopter.

After presenting the general scenario, discuss it as a class. Be sure as many technological aspects of the scenario are brought up as possible, from the initial accident to the hospital stay to the return home after being discharged. The students should realize that technological developments have made significant impacts on the lives of people, sometimes for good (helicopter transportation, air bags, instantaneous communication) and sometimes having negative effects (injuries in a wreck, increased cost of medical attention). The section students will be studying first is how informational systems function and their different types.

Narrative

Discuss the components of an information system; describe to students how a telephone works. Most technology education textbooks discuss the technological systems model. See the "Cell Phone System" activity. To relate this content to the innovation unit, review the development of the telephone from its inception up to the present-day cellular phone. The teacher could bring a cellular phone to class and demonstrate its operation to the students. Also, a cellular phone company representative could be contacted to be a guest speaker. The representative could describe analog and digital phones, how the information is transmitted, and how the industry has grown.

"WOW-Com, Wide World of Wireless Communications" is devoted to providing information about cellular communications and is sponsored by the Cellular Telecommunications Industry Association. On the consumer page there is helpful material about how to drive safely with a cell phone, hands-free devices, frequently asked questions, consumer tips, and how wireless works. In addition, statistics and surveys, laws, 911 statistics, and news about cell phones can be found from the main page. http://www.wow-com.com/

Show the students a variety of messages and discuss their audience, purpose, method of transmission, and cost. For instance, show an advertisement from television, radio, newspaper, website, billboard, magazine, or piece of clothing. This is also a good time for the students to understand how the elements of a message are important regardless of its method of transmission. The "Message Broadcast" or similar activity will aid in the development of this understanding. *911 Magazine* provides a page entitled *Some Tips when Dialing 911* that clearly describes the steps someone should follow when dialing 911. This is an important set of procedures with which all individuals should be familiar. http://www.9-1-1magazine.com/info/resources/911tips.html

Finally, have students use the database created in the "Informational Database" activity to compile a sample 911 database. To make the scenario more realistic, invite a local dispatcher from the 911, police, or fire department to speak to the class about these issues. They should discuss how directions are mapped, information is retrieved, and medical assistance is given over the telephone.

Content Outline

I. **Information Systems**
   A. Input
      1. Message encoded
   B. Process
      1. Message transmitted
   C. Output
      1. Message decoded
   D. Feedback
      1. Clarity of message
      2. Message sent back to first speaker

II. **Designing Messages**
   A. Audience
   B. Purpose
      1. Inform
      2. Persuade
      3. Entertain
      4. Educate
      5. Control tools and machines
   C. Cost
   D. Elements
      1. Balance
      2. Contrast
      3. Rhythm

III. **Methods of Transmission**
   A. Video
      1. Television
      2. Kiosk
      3. Computer
   B. Audio
      1. Radio (1-way & 2-way)
      2. Telephone
      3. Music
      4. Computer
   C. Graphic/Print
      1. Newspaper
      2. Billboard
      3. Facsimile
      4. Photography

Suggested Learning Experiences

Cell Phone System – Divide the class into eight cooperative learning groups. Two groups will each look at one of the components of an informational system with regard to a cellular phone. Then, groups of four should be formed in the class, with each person representing one of the aspects of the systems model. Students with special needs may be paired with other students who studied the same system component. Then each group of four should design a poster that displays the system model. This process follows the Jigsaw II cooperative learning model. (See RB-04, Page 30)

Information Services – The students will examine how voice communication systems (wired and wireless) transmit a message and trace its historical development. The website entitled, "WOW.com," provides current information about cell phones for the consumer.

Message Broadcast – In groups of three or four students, design and produce some form of a broadcast that either reports on the car accident or could be used to help prevent accidents in the future. This can be done for radio, television, or print media. See Activity 10 in *Teaching Technology: Middle School.*

Informational Database – Have the class work collectively to create a simple computer database that could simulate one that an emergency response person may have when he or she receives a phone call. The database could also be used to help diagnose and treat injuries while on the telephone. Include fields such as name, address, age, family members, house color, pets, handicaps, and phone number. Students should be encouraged to create two or three fictitious families so as to protect their privacy.

Dispatch Expert – Invite a dispatcher from an ambulance crew, hospital, police, or 911 center to speak to the class. In particular, make sure the individual brings in and demonstrates to the class equipment that he/she uses on a day-to-day basis. They should also show how these devices operate and discuss how they have changed over the past decade. To conclude the lesson, the students should do a mock 911 scenario with the dispatcher and the database they have compiled as a class. Use the website by the *911 Magazine* described previously for more information.

Section 4-B: Transportation

Overview

The injured passengers will need to be transported by an ambulance or helicopter. Some ambulances (like the ones in this scenario) and helicopters use a vehicle locator system so the central communications network can track the vehicles. This technology allows hospitals to quickly predict the arrival time and reroute the vehicle if there is congested traffic on their proposed route. What kind of equipment is required in an ambulance or medical helicopter? As the characteristics of transportation technology are explored, students will recognize that all vehicles utilize similar systems to complete their route. In addition, students will design and construct a vehicle that replicates an ambulance of the future, but is powered solely by electricity (9-volt battery).

Narrative

To begin this unit about transportation, students will review the systems model that was used when studying the informational system and then identify the inputs, processes, outputs, and feedback as they relate to transportation. In addition, students should study transportation environments. The "Transportation in the News" activity should help with both of these items. "History of the Helicopter" is sponsored by Langley NASA Research Center. This site provides a seven-part series about the historical developments of the helicopter that contains both video clips and textual information. http://lava.larc.nasa.gov/ABSTRACTS/LV-1998-00125.html

To further the investigation of transportation, students will design and construct an ambulance that is powered solely by electricity. See the "Electric-Powered Ambulance" activity for further explanation. This will also provide students an introduction to implement their designs.

Content Outline

I. Transportation Systems
- A. Input
- B. Process
- C. Output
- D. Feedback

II. Transportation Environments
- A. Land
- B. Water
- C. Air
- D. Space

III. Vehicle Modeling
- A. Safety
- B. Materials
  1. Balsa Wood
  2. Styrofoam
- C. Tools
  1. Cutting Tools-Saws, X-acto knives
  2. Shaping Tools-Files
- D. Adherents
  1. Glue
  2. Tape

Suggested Learning Experiences

Transportation in the News – Distribute to each of the students a newspaper and ask them to locate an advertisement or article that relates to transportation. Generally, students will find that the information is organized into four different transportation environments (land, water, air, and space). They should take the articles and summarize them for the class in the form of a radio advertisement. This article will also help the students realize that transportation has a significant impact on our society.

Electric-Powered Ambulance – Begin by discussing with the class the importance of modeling in technology, especially in transportation. In this activity they will design, construct, and test a vehicle that is powered only by a battery. The battery size should not exceed a single 9-volt battery. Students should focus both on modeling details and making a vehicle that would simulate an ambulance. Be sure to emphasize safety while using the tools and materials.

Section 4-C: Construction

Overview

One of the injured passengers will be required to be in a wheelchair upon returning to his home. In order for him to enter the home, a ramp needs to be constructed to improve safe home accessibility. Since the ramp may be needed temporarily, it should be easy to adapt in other locations and transportable. Students will design and build a model of an access ramp for a building in their community or in a home.

Narrative

Begin by presenting basic information about construction systems. A video about construction or the building trades could be used to show major construction areas. The *Exploring Technology Education* (1990) video series contains a four-part video about construction. It features an introduction to construction, designing and planning a structure, building a structure safely, and finishing a structure. Discuss with students how various parts of a structure might have to be modified to accommodate a person with special needs.

Content Outline

I. Construction Systems
- A. Input (Information, People, Materials)
- B. Process (Planning, Funding, Designing, Contracting)
- C. Output (New or Improved Structure)
- D. Feedback (Change Orders, Maintenance, Future Expansions)

II. Basic Construction Principles
- A. Materials
  1. Tension
  2. Torsion
  3. Elasticity
  4. Shearing
- B. The Structure
  1. Triangle Shape
  2. Foundation
  3. Trusses

III. Americans with Disabilities Act (ADA)
- A. History
- B. Public Access
  1. Regulations
  2. Enforcement

Suggested Learning Experiences

Ramp Construction – Students will need to have a basic understanding of codes and regulations when constructing a building. They will need to design and construct a ramp so this individual can enter his/her home or a community building in a wheelchair. “The Home Ramp Project” is a website that describes the basics when designing and constructing a modular wheelchair ramp for a house or public building. From this site there are also links to web pages about safety, success stories, additional print resources, and information about cost and funding a ramp. http://www.dragnet.org/rampman/rampman.htm

Section 4-D: Medical Technology

Overview

In the final scenario, the individual with the severely broken arm must have it amputated. Since this person will need to use it in conjunction with his other arm, an artificial limb needs to be designed. For the time being the limb should be able to do common tasks (picking up a can of soup, turning on a light switch, and picking up a coffee mug). Students will need to investigate how artificial limbs operate and then design and construct a basic model.

Narrative

Begin by discussing with students what medical technology is and its impacts on society. Review examples of inventions and inventors from the beginning of the course. Have students identify the inputs, processes, output, and feedback of various medical technologies. The main activity in this unit is for students to understand how the body functions mechanically. For instance, the hip is simply a ball-and-socket joint and the fingers and elbow are pinned joints. They could then perform simple human measurement studies on themselves, as in the "Human Measurements" activity. This information will be used as students design a prosthetic arm. Study results can be compiled and the mean, median, and mode of body part sizes calculated. The teacher can show students how to calculate proportions between various parts among and within groups of students.

Content Outline

I. **Medical Technologies**
   A. Life Enhancement and Support
   B. Vaccines and Pharmaceuticals
   C. Diagnostics, Treatment, Rehabilitation
   D. Genetic Engineering

II. **Anthropometrics**
   A. Measuring Principles
   B. Ergonomics
   C. Prosthetics

Suggested Learning Experiences

Human Measurements – Anthropometrics is the study of human body size and motion. Have each student measure his or her foot length, hand span, angle of elbow movement, length from one fingertip to the other with arms horizontal, finger length, and others the instructor may desire. Students can document measurements by sketching body parts and adding dimensions.

Developing and Using a Prosthetic Hand – This activity can be found on page 91 of *Integrated Mathematics, Science, and Technology (IMaST)*. In this activity, students trace their hands, add rubber bands to the outside, and strings threaded through straws on the inside. They will need to manipulate the hands to perform various tasks (gripping a mug, tying a knot, or turning a doorknob). Arm Dynamics is a site devoted to individuals who are in need of an upper-arm extremity. It contains a glossary, statistics, and resources for individuals who have an amputated limb. http://www.armdynamics.com

Unit 5: Explorations in Technology

Overview

Middle level students have a natural curiosity for exploring how things work. As these students move into the formal operational phase of learning described by Piaget, they want to explore the world around them through mental manipulations and abstract thinking. This unit engages the students' natural curiosity and changing thought processes by examining technological devices, products, or systems in various contexts. Each section presents and applies one or more core principles of technology to products and systems in the designed world. Students will learn that decisions about technology involve applying core principles such as systems, resources, requirements, processes, optimization, trade-off, and controls. The final activity integrates and reinforces these principles through application.

Enduring Results

***STL* Standards and Benchmarks**

1. Develop an understanding of the characteristics and scope of technology. (Standard #1).
   a. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (Benchmark F).
   b. The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative. (Benchmark G).
2. Develop an understanding of the core concepts of technology. (Standard #2).
   a. Technological systems include input, processes, output, and at times, feedback. (Benchmark M).
   b. Systems thinking involves considering how every part relates to others. (Benchmark N).
   c. Technological systems can be connected to one another. (Benchmark P).
   d. Malfunctions of any part of a system may affect the function and quality of the system. (Benchmark Q).
   e. Requirements are the parameters placed on the development of a product or system. (Benchmark R).
   f. Trade-off is a decision process recognizing the need for careful compromises among competing factors. (Benchmark S).
   g. Different technologies involve different sets of processes. (Benchmark T).
   h. Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. (Benchmark V).
3. Develop an understanding of the effects of technology on the environment. (Standard #5).
   a. Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. (Benchmark F).
4. Develop an understanding of the role of society in the development and use of technology. (Standard #6).
   a. Social and cultural priorities and values are reflected in technological devices. (Benchmark F).
   b. Meeting societal expectations is the driving force behind the acceptance and use of products and systems. (Benchmark G).
5. Develop an understanding of engineering design. (Standard #9).
   a. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. (Benchmark H).
6. Develop abilities to use and maintain technological products and systems. (Standard #12).
   a. Use information provided in manuals, protocols, or by experienced people to see and understand how things work. (Benchmark H).
7. Develop abilities to assess the impacts of products and systems (Standard #13).
   a. Design and use instruments to gather data. (Benchmark F).
   b. Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology. (Benchmark G).
   c. Interpret and evaluate the accuracy of the information obtained and determine if it is useful. (Benchmark I).

Acceptable Evidence

1. Create sketches and drawings, with annotations, that show how the product or device is created.
2. Develop an improved product or device based on the evaluation and study of an existing item.
3. Discuss how the product or device impacts people in the present and future.

Student Preparation

Students may begin this unit by brainstorming a list of their favorite products and devices. Items may include packaged foods, entertainment devices, articles of clothing, or forms of transportation. Students could select a single product to explore in detail.

Suggested Learning Experiences

The learning experiences in each section are designed to accompany the "Overview" general scenario. Examples of appropriate learning experiences are given. The technology teacher has the option of selecting from comparable activities that:

- Align with technological literacy standards;
- Provide a cohesive structure to the entire curriculum;
- Connect in a variety of ways to technology content, other activities, and to other fields;
- Engage students actively as they design and construct a product or system during the unit.

Academic Connections

Mathematics

1. Algebraic Equations – Compare the time and speed differences between a magnetic levitation vehicle, plane, train, and automobile. In addition, consider cost and the danger involved. Also, students could calculate the efficiency of various products or systems.
2. Graphing – Students can prepare a graph that depicts the number and types of containers recycled in one week at home.
   - http://library.thinkquest.org/20991/prealg/graph.html – A review of how to create a variety of graphs
3. Cost Calculations – Products and systems have direct and indirect costs associated with them. Students can determine costs associated with designing, creating, and using a product or system. Cost comparisons can be made for similar products.

Science

1. Material Science – In what ways do materials differ? Compare key characteristics of materials.
   - http://www.matweb.com/ – Free materials information database with property data on many different materials
2. Magnetism – Depict in a drawing how magnets on the maglev track are used to propel the vehicles forward.
3. Fluids – Create a diagram that shows the movement of fluids in a home.
4. Energy – Students can study laws concerning conservation of energy in a system.

Social Sciences

1. Consumerism – Describe how selected products have affected people's lives and the environment.
2. Personal Safety – Discuss how consumers are protected from faulty or dangerous products.
3. Transportation – The magnetic levitation train would greatly improve the time it takes to travel. There are, however, some geographical and societal ramifications that should be studied as students design and build the model of a magnetic levitation vehicle.
4. Environment – Recycling is mandatory in some localities. Students should investigate the regulations related to recycling in their locality and make sure that they are abiding by the statutes.
   - http://grn.com/ – The global recycling network
5. Safety in the Workplace – Students could investigate safety criteria and constraints for selected processes and materials handling set forth by OSHA.
   - http://www.osha.gov/ – The Occupational Safety and Health Administration web page

Language Arts

1. Technical Writing – Students could write technical instructions for how the Mag-Lev transportation system works. Emphasis should be placed on incorporating appropriate technical terminology.
2. Persuasive Writing and Speaking – Create a radio advertisement to inform citizens in the community about the importance of recycling and local regulations.
3. Communications – Make comparisons of how products appeared 25 years ago and how they are used today. This could be written in a report, conveyed through dramatization, or developed as a multimedia presentation.

General Scenario:
You have been hired as an industrial designer by a national firm. Your job is to improve selected products to meet people's needs for safety, comfort, ease of operation, reasonable cost, and recyclability. In order to do this job, you will need to know the history of the product or device, how it works, and how people use the product or device. Your new and improved version of the product or device must have consumer appeal in addition to meeting people's needs and wants.

Unit Section Overview

Section 5-A, Systems: Systems are made up of interrelated parts that are designed to work together to achieve a goal. Systems that may be found in products and devices are: mechanical, electrical, fluid, and chemical systems. They may also be categorized according to the technologies they represent such as medical, transportation, or informational systems. In this section, students will explore different systems in products and devices and how they work together.

Section 5-B, Resources: Resources are the things you need to get a job done. Technological resources are tools and machines, materials, information, energy, capital, time, and people. Materials may be natural or produced by people. Materials are selected according to their characteristics. Products and devices may have a combination of a variety of materials. Students will examine the kinds of resources that contribute to the design and creation of a product or system.

Section 5-C, Requirements: These are the criteria and constraints for developing a design into a product or a system. Students will find out that every design has a set of requirements.

Section 5-D, Optimization and Trade-off: Optimization is a process that involves making the best possible product or system. Tradeoff involves making choices between product requirements in order to meet requirements. In this section, students will learn that design is an iterative process and that designs are being constantly improved. Also, students will learn that a number of decisions must be made between one set of qualities and another.

Section 5-E, Processes and Controls: These are a set of actions that are used to combine resources in order to develop an invention or innovation. Students will become acquainted with processes used in different technologies to create and implement designs. Controls are mechanisms or activities that cause a system to change. Students will learn about how controls are used to manage technological systems.

Section 5-A: Systems

Overview

Students will examine technological designs, products, and devices in terms of systems. Students will find out that systems are made up of interrelated parts that are designed to work together to achieve a goal. Products and devices have systems such as: mechanical, electrical, fluid, and chemical systems. Systems may also be categorized according to the technologies they represent such as medical, transportation, or informational systems. In this section, students will explore different systems in products and devices and how they work together to meet people's wants and needs.

Narrative

Begin the unit by reviewing some of the concepts learned in the "Technological Innovation" unit. This can be done by having students write a short reflection of what they learned during that unit and seeing if there are still outstanding questions. If students have been developing a log or portfolio, they may want to refer back to it for specific information and examples. It is important that students realize that all products come from one of three realms: invention, innovation, or discovery. Discuss each of these with the class to ensure they have a strong understanding of these concepts. At this time, it would also be appropriate to review the definition of a system and provide examples.

Discuss with the class the five systems that will be studied (mechanical, electrical, fluid, thermal, and chemical). It is important that they see how these systems work independently and collectively. To provide an example that all students understand, discuss the systems that exist in your school building. Then, have the students work on the "Product Dissection" activity described.

Content Outline

I. **Product Creation**
   - A. Inventions
   - B. Innovations
   - C. Discovery

II. **Systems**
   - A. Mechanical – Action and forces between physical objects
   - B. Electrical – The flow of electrons in an object
   - C. Fluid – Movement of a gas or liquid.
   - D. Thermal – Effects created by heat or cold
   - E. Chemical – Composition, structure, and properties of matter

Suggested Learning Experiences

Product Dissection – This activity relies on the "Discovery Learning Approach" developed by Jerome Bruner. Basically, students learn by doing. Each student or group of students is to bring in one product that can be taken apart and will not need to function again. First, they should describe what it was intended to do and list the procedures needed to operate it. Then, as pieces are taken apart step-by-step, each maneuver should be recorded with sketches or annotations. The goal is for students to identify as many of the systems as possible that exist in their device and gain a basic understanding of how each system operates. Be very careful that, if the product was electrical in nature, students do NOT attempt to plug it back into an outlet. Finally, have each group share with the class what they learned about their product and how it works. All products should be collected by and properly disposed of by the instructor at the end of the activity. (TB-01, Page 119)

Section 5-B: Resources

Overview

In this section, students will examine the kinds of resources that contribute to the design and creation of a product or system. They will discover that there is a wide range of resources, which in combination contribute to the effectiveness of a technological design. Students will learn that there are many decisions to be made involving resources and their responsible selection, application, and disposal.

Narrative

Use one of the products from the "Product Dissection Activity" to present technology resources. Explain to students that resources are the things you need to create or innovate products and systems. Technological resources are tools and machines, materials, information, energy, capital, time, and people. Discuss how materials may be natural or produced by people. Provide examples of different materials. Use questioning techniques with students to explore how materials are selected for specific products according to their characteristics. Products and devices may consist of a combination of natural and human-created materials.

Content Outline

I. Technology Resources
- A. Tools and Machines
- B. Materials
  - 1. Natural
  - 2. Human-created
- C. Information
  - 1. Data
  - 2. Information Types
- D. Energy
  - 1. Renewable
  - 2. Nonrenewable
- E. Capital
- F. Time
- G. People

II. Selecting Resources
- A. Design
- B. Cost
- C. Product Life

Suggested Learning Experiences

Product Look-Alike – Have students select a simple product design that can be made out of different resources. Product examples could include a drinking cup, portfolio folder, computer disk sleeve, airplane model, cosmetic bag, or wallet. Have students make prototypes using different resources. Provide students with a chart that provides a resource type for each row and a product version for each column. Students can use this chart to record the different resources that were used. Have students compare resources and explain which set of resources produced the best results.

Resource Innovations – Have students research a specific resource to find out how resources have impacted technology. Examples could be space-age materials, designer metals, wireless or cordless tools, or alternative energy resources. Students can create a media commercial, poster, or fictitious website to promote the selected resource. See http://www.matweb.com/ for a free materials-information database with property data on many different materials.

Metal Fatigue – In this activity, students will test the fatigue of various metallic items. Be sure to inform students of safety procedures prior to testing metals. Metallic items include a paper clip, staple, piece of solid copper wire, or a pin. They will bend it continuously and count the number of times it takes until the item breaks in half. This should be done for each item at least three times. This concept of metal fatigue can then be related to destructive and non-destructive testing practices in industry. Finally, this information can be entered into a spreadsheet and comparisons made between the various items (Adapted from TB-01, Page 160).

Plastic Processes – Students live and interact with plastics every day. In this activity, they will locate and distinguish between thermosetting, thermoplastics, and elastomers. Begin by asking students to bring in at least five different items that contain plastic. As a class, they should then work collectively to categorize them into the three areas of plastics. Discuss with the class the advantages and disadvantages of using each type of plastic material.

Section 5-C: Requirements

Overview

Every design has a set of requirements to guide the development of the design into a product or system. These requirements are in the form of criteria and constraints. Students will explore requirements for various designs. Also, students will have the opportunity to experience establishing criteria and constraints for a design activity.

Narrative

Review resources that were presented in the previous section. Ask students to brainstorm reasons why they selected particular resources for their products. Examples may include durability, cost, availability of resources, and time needed to produce the item. Explain to students that materials are selected according to specific requirements. Requirements are the criteria and constraints for developing a design into a product or system. Criteria are the desired elements and features of a product. Constraints are the limitations of a design. Students need to understand that every technological design has a set of requirements.

Describe the design brief process to students. Identify the major activities in this process: identifying the problem, identifying criteria and constraints, exploring alternative solutions, selecting the best solution, implementing the solution, and evaluating the effectiveness.

Content Outline

- **I. Requirements**
  - A. Design Criteria
  - B. Safety
    - 1. Personal health
    - 2. Protection from injury
  - C. Application
    - 1. Ergonomics
    - 2. Function
  - D. Product Characteristics
    - 1. Durable
    - 2. Recyclable
    - 3. Easy to Use
    - 4. Reliable
- **II. Design Constraints**
  - A. Available Resources
  - B. Cost
  - C. Environmental Concerns
  - D. Alternative Resources
  - E. Production Time
  - F. Legal, Ethical Considerations
  - G. Public Acceptance

Suggested Learning Experiences

Design Brief Activity – Place students in groups of three or four. Introduce a design brief activity to the students. Have each group of students identify criteria and constraints for the design in their portfolio. Students will implement their selected design to achieve a final solution. Have students revisit the criteria and constraints to determine if the stated requirements were sufficient or if additional requirements were necessary. The materials listed in the "Resources" section may be used to find design briefs for the students. Be sure that they contribute to attainment of the standards for this unit and are age-appropriate. (TB-02, Chapter 2)

In the News – Have students find a news article evaluating a new or popular product on the market. Students can highlight design criteria using one color of highlighter pen and highlight design constraints using another color. Have students work in pairs to compare information. Students may find that some articles accentuate design criteria while others may focus only on constraints.

Section 5-D: Optimization and Trade-offs

Overview

Design is a process that is continuous. Technological systems and products are tested and redesigned to make them more effective. Optimization is a process involving making the best possible product or system. Trade-offs involve making choices between one quality or another in order to meet requirements. In this section, students will find out that design is an iterative process and that designs are constantly improved upon. Also, students will learn that a number of decisions must be made between one set of qualities and another.

Narrative

Exploration of our designed world includes understanding that no design is perfect and that a design may go through many iterations before a product, system, or device enters the consumer market. Many products never make it to the store shelves. In this section, students will become acquainted with optimization and trade-offs as important core concepts of technology. Optimization is a process involving making the best possible product or system. Trade-offs involve making choices between one quality and another in order to meet requirements.

Provide different models or types of a single product. You may want to use athletic shoes or book bags to illustrate optimization and trade-offs. For example, athletic shoes are designed for different purposes. Running shoes are designed to be light yet sturdy and absorb repeated shock. Certain parts of the shoes are reinforced for comfort and limited durability; avid runners often have to replace shoes every few months. Book bags, as another example, must be designed to hold a day's worth of books and supplies without breaking. Shoulder straps must be comfortable and durable. A major constraint is that the book bags must not be capable of holding loads greater than what the user can carry.

Content Outline

I. Optimization
- A. Definition
- B. Process of making the best possible design
- C. Prototyping, Testing

II. Trade-offs
- A. Definition - Comparing and choosing qualities
- B. Examples - Athletic shoes
- C. Testing, Evaluating, Retesting

Suggested Learning Experiences

The Way Things Work – This activity refers to the title of a book and CD-ROM published by Houghton-Mifflin and written by David Macaulay. It illustrates, in cartoon-like fashion, how varieties of devices work. Students should select one of the devices from the book or CD-ROM and write a short description of how the object works. Once collected by the teacher, the descriptions should be redistributed to the class so each student has a different device. Ask students to brainstorm how the product can be optimized. Also, have students discuss trade-offs that are involved in designing their particular device. This process can be followed a few times. Once complete, the descriptions should be given back to his/her owner so he/she can do additional research to answer the questions on the paper. At the end, all students should give a short presentation about their device. If possible, encourage students to bring in the actual device for their presentation. For additional references, see the following websites:

- "How Stuff Works" contains hundreds of articles about how technological devices and systems work. http://www.howstuffworks.com/index.htm
- "The Way Things Work" contains examples from the book and interesting facts about all types of devices. http://www.waythingswork.com/

Section 5-E: Processes and Controls

Overview

In exploring technology, students will use a variety of processes for creating, using, managing, and evaluating technology. In this section, students will learn more about processes and how controls are used to manage technology. Processes are a set of actions that are used to combine resources to develop an invention or innovation. Students will become acquainted with processes used in different technologies to create and implement designs. Controls are mechanisms or activities that cause a system to change. Students will learn about how controls are used to manage technological systems.

Narrative

In this section, students will be acquainted with the core concepts of processes and controls and how they impact technological products and systems. Students will experience how various processes contribute to the implementation of a design. In addition, students will learn about how controls are used to manage technological products and systems.

In carrying out a design, a variety of processes is used. Processes are sets of actions that are used to combine resources to develop an invention or innovation. Different technologies use different processes. Using the design brief solutions from the previous section activity, discuss various processes that were used to transform resources into the completed design. Use examples from different technologies, such as medical or informational, to show how processes may differ depending upon what resources are used.

Using a system that students may encounter in their home or at school, identify the parts of the system, including controls. Explain that controls are mechanisms or activities that cause a system to change. Have students cite examples of controls in various systems. Examples may be switches in electrical systems, valves in hydraulic systems, or actuators in mechanical systems.

Content Outline

I. Processes
- A. Designing
- B. Making
- C. Controlling
- D. Maintaining
- E. Assessing

II. Controls
- A. Electrical
- B. Mechanical
- C. Hydraulic
- D. Pneumatic

III. Applications in Technologies
- A. Medical
- B. Agricultural and Related Biotechnologies
- C. Energy and Power
- D. Information and Communication
- E. Transportation
- F. Manufacturing
- G. Construction

Suggested Learning Experiences

Processes in Transportation – Students will apply various processes and controls in designing and creating a vehicle that travels on a magnetic levitation track. The track can be constructed in a variety of ways (see TB-01, Page 297). Students can test a variety of magnets and determine which setup works most efficiently. This can be done by timing each car with varying amounts of weight applied to the vehicle. To provide propulsion for the vehicle, raise the track so it is inclined, causing the gravitational force to move the vehicle. An extension of this activity is to have the students design and make a starting gate that is moved by a solenoid in order to control the vehicle. See http://www.maglev.com/english/index.htm for information about a German company that is involved in magnetic levitation research and development.

Home Water System – Have students analyze the water systems in their homes, to find out if water is used for heat and/or drinking, where it comes from, and what happens to it after it has been used. They can compare answers with other students in the class. Next, give students, in groups of three or four, a floor plan of a house without plumbing symbols on it. Students could use colored pencils to represent hot, cold, and wastewater pipes on the floor plan. If possible, give them a second floor plan and ask them to do the same thing, making sure to consider what is on the first floor. Finally, an architect or contractor can be invited to explain plumbing systems. (TB-08, Chapter 37)

The Make-up of a Thermostat – A thermostat monitors the temperature in a room and sends a signal to a furnace or air-conditioning unit. How does it function? Have students open the front of a thermostat and make a sketch of what they see. Describe how, when the mercury gets cooler, it contracts and contact is made. This sends a signal to the furnace to turn on. Contact remains until the mercury heats up again and the contact is broken. Students could use a CAD program to create a drawing of the thermostat. If time is available, students could make their own thermostats. See http://www.energy.ca.gov/education/projects/projects-html/thermometer.html.

Section 5-F: Recycling

Overview

Students will have the opportunity to apply each of the core concepts in the context of a recycling activity. Students will learn how many concepts contribute to a better understanding of technology – its creation, development, management, and assessment. Further, the section activity enhances students' awareness of the consequences and impacts of technological systems, resources, requirements, processes, and controls on the environment and in their daily living.

Narrative

The final section in this unit is about recycling, a topic that cuts across technologies and incorporates the core concepts. All students should consider this topic before they design and create new technological devices and systems. Have students brainstorm definitions for recycling. Discuss positive and negative aspects of recycling. Ask students to give an example or two of how they have recycled in the past day. Introduce students to the "Degradation and Recycling" activity. The purpose of it is to make students more aware of the slow process of degradation that is occurring at a landfill. Then encourage students to find more ways to recycle items that they commonly throw away.

This activity could be part of a school or community recycling program. Guest speakers from local government or community organizations can be invited to discuss area recycling efforts and potential impacts. Area technology companies can be contacted regarding recycling programs.

Content Outline

I. Recycling
- A. Systems
- B. Resources
  - 1. Materials
    - a. Paper
    - b. Plastic
    - c. Cans
    - d. Glass
    - e. Oil
    - f. Organic material-food
  - 2. Energy
  - 3. Tools and Machines
  - 4. Other
- C. Requirements
  - 1. Available land
  - 2. Environmental Concerns
  - 3. Safety and Health
- D. Optimization and Trade-offs
  - 1. Manufacturing materials
  - 2. Cost
  - 3. Storage
- E. Processes
  - 1. Recovery, recycling, reclamation
  - 2. Incineration
  - 3. Composting, Landfills
- F. Controls
  - 1. Bio-organisms
  - 2. Chemicals

Suggested Learning Experiences

Degradation and Recycling – This activity compares photodegradability and biodegradability of a material. Students should have an opportunity to visit a landfill or waste treatment facility to see how it operates. Many of them will be surprised at the quantity of garbage that is being buried or processed. Working in groups of three or four, students could use a small area of land or a large fish tank to create a simulated landfill. They can select food, clothing, paper, or other items they commonly throw away and bury them in their "landfill." Cover the items with soil and tamp it down. Be sure to mark off the area if it is outdoors. Students will check the items twice a week for about eight to ten weeks and record the changes that have taken place in each item. Be sure to relate the chemical changes they are recording, and try to determine why they happen with some items and not with others. (Adapted from RB-05, Page 13; TB-01, Page 167)

The Environmental Protection Agency has information about recycling and environmental issues.
See http://www.epa.gov/.

Chapter 3

Instructional Resources

Chapter 3

Instructional Resources

Textbook Resources

TB-01
Technology
B. Thode, & T. Thode
Published by Glencoe/McGraw Hill, 1994.

This textbook contains 16 chapters that include information about technology-related careers, hands-on and minds-on activities, interesting "Technofacts," and integrated material from math, science, and language arts. Design and problem solving provide a common thread throughout the reading and activities.

TB-02
Technology, Today & Tomorrow
J. Fales, V. Kuetemeyer, and S. Brusic
Published by Glencoe/McGraw Hill, 1993.

This textbook contains 25 chapters that are organized into five main sections: communication, manufacturing, transportation, construction, and biotechnology. Students learn about changes that have occurred in technology, how they impact our lives today, and potential advances for the future.

TB-03
Experience Technology: Communication, Production, Transportation, Biotechnology
S. Soman and N. Swernofsky
Published by Glencoe/McGraw Hill, 1993.

The 31 chapters provide for an experiential journey through the world of technology. Students not only learn by the content provided in the chapters, but also through "doing" a wide variety of interesting and challenging activities.

TB-04
Introduction to Design and Technology
R. Todd, K. Todd, and D. McCrory
Published by Glencoe/McGraw Hill, 1996.

This book is designed for middle school level children. It focuses on the study of technology through the design process as it relates to knowledge, results, and impacts. The book contains 15 chapters and is divided into four sections: Design of Technology, The Resources of Technology, The Systems of Technology, and The Impact of Technology.

TB-05
Design and Problem Solving in Technology
J. Hutchinson and J. Karsnitz
Published by Glencoe/McGraw Hill, 1994.

Thirteen chapters provide the framework from which students gain knowledge, processes, and skills necessary for understanding technology. The book grows out of the belief that design and problem-solving skills can be learned by all students and that these skills can lead to an in-depth understanding of technology, as well as other areas of study.

TB-06
Integrated Mathematics, Science, and Technology: Wellness
Center for Mathematics, Science, and Technology Education (IMaST)
Published by Glencoe/McGraw Hill, 1998.

This book focuses around the topic of wellness, from an integrated perspective. Students use a five-step problem-solving process (Define, Assess, Plan, Implement, and Communicate) to develop solutions in three different wellness themes: Nutrition, Exercise, and Communicable Disease. The book is organized into content area sections with activities, content, and assessments interconnected.

TB-07
Integrated Mathematics, Science, and Technology: Food Production
Center for Mathematics, Science, and Technology Education (IMaST)
Published by Glencoe/McGraw Hill, 1998.

Food Production is studied in this book, using an integrated mathematics, science, and technology approach. Five main food production themes are used for the content: Select, Prepare, Propagate, Nurture, and Harvest food. This book uses a five-step problem-solving process: Define, Assess, Plan, Implement, and Communicate.

TB-08
Residential Architecture: Design and Drafting
E. Weidhaas and M. Weidhaas
Published by Delmar Publishers (1999).

This book provides a broad overview of the study of architecture and drafting. Although not specifically intended for middle-level students, there is a tremendous amount of information that is useful for this course. Relevant topics include Architectural History, CAD, Architectural Design, and Working Drawings. Text boxes throughout the book highlight careers, Internet connections, and connections to other academic studies.

TB-09
Design Brief Manager Software
D. Engstrom and L. Hatch
Published by Glencoe/McGraw Hill, 1995.

This computer program is a database of over 100 design activities. Teachers can organize, store, retrieve, print, and export design briefs for students in different grade levels. It is intended to accompany *Introduction to Design and Technology*.

TB-10
Understanding and Using Technology
R. Todd, D. McCrory, and K. Todd
Published by Davis Publications, 1985.

This book was the predecessor to many of the design and technology books. It examines the study of technology in four sections: Elements of Technology, Activities of Technology, Changes of Technology, and Impact of Technology.

TB-11
Understanding Technology
T. Wright and H. Smith
Published by Goodheart-Willcox, 1998.

In the 14 chapters of this book, students are introduced to technology through systems. It does more than just describe technology, as carefully designed end-of-chapter activities are included. In addition, the effects of technology are woven into each chapter so students realize the impacts and consequences of technology.

TB-12
Technology: Shaping Our World
J. Gradwell, M. Welch, and E. Martin
Published by Goodheart-Willcox, 1996.

This book was written to help students understand the technological world around them. It introduces students to various technologies and shows how they have used basic scientific principles. In addition, the information in the 14 chapters helps students to realize that technology has significant impacts on individuals, society, and the environment.

TB-13
Design and Problem Solving
P. Sellwood and P. Hutchinson
Published by Glencoe/McGraw Hill, 1996.

This booklet is part of the TechKnowledge Reference Series. The main emphasis is how people design solutions to technological problems in a variety of contexts. A variety of design briefs, "technoterms," interdisciplinary connections, and visual examples are presented in this easy-to-read, highly illustrated, colorful booklet.

Reference Book Resources

RB-01
Teaching Technology: Middle School
Published by ITEA, 2000.

This standards-based guide is a compilation of methods, activities, and resources for teaching technology in the middle grades. The document will assist teachers in preparing to implement *Standards for Technological Literacy: Content for the Study of Technology*. It should be used to support implementation of this course.

RB-02
A Guide to Develop Standards-Based Curriculum for K-12 Technology Education
Published by ITEA, 1999.

This publication is intended to provide the guidance for curriculum developers, decision-makers, and teachers to develop a contemporary, standards-based curriculum framework for technology education, grades K-12. The content and curriculum thrusts in this publication reflect the collective vision of leaders in technology education representing different regions and localities.

RB-03
Integrated Mathematics, Science, and Technology, Phase II: Animal Habitats
Center for Mathematics, Science, and Technology Education (IMaST)
Published by Glencoe/McGraw Hill, 1998.

This is a nine-week module that is filled with exciting integrated activities. Students will learn about ecosystems, animal living environments, animal habitats, and how to develop actuarial tables. In addition, students will use this information to design and construct an animal habitat enclosure, structure, or platform.

RB-04
Technology Learning Activities I
Published by ITEA, 1993.

This booklet contains a collection of 31 different technology learning activities for a variety of grade levels and technology education courses. Each activity contains a background, context, objectives, challenge, materials and equipment needed, the challenge, limitations, notes and investigations, resources and references, and evaluation suggestions.

RB-05
Technology Learning Activities II
Published by ITEA, 1995.

This booklet contains a collection of 23 different technology learning activities for a variety of grade levels and technology education courses. Each activity contains a context, objectives, materials and equipment needed, the challenge, and evaluation suggestions.

RB-06
Technology's Past
D. Karwatka
Published by Tech Directions Books, 1996.

This heavily-illustrated book contains information about 76 fascinating inventors and innovators and their work. Topics include radio, skyscraper, outboard motor, ac electricity, computers, robots, and the television.

RB-07
Technology's Past, Volume Two
D. Karwatka
Published by Tech Directions Books, In Press.

This book will be very similar to the first release. More inventors, innovators, and their work will be described and illustrated.

RB-08
The Way Things Work (Volumes I and II)
D. Macauley
Published by Houghton-Mifflin, 1991 and 1998.

Each of these books examines how technological devices work using cartoon-like figures. Descriptions and illustrations make each book easy to understand for middle-level children.

RB-09
Design and Technology
Technology Education Service
Published by the Virginia Department of Education, 1992.

Although this curriculum is designed for grades 9 to 12, many of the design activities can be adapted for middle-level school. The program consists of three courses designed to help students acquire and use technological knowledge, apply the technological method and systems, and assess the impacts of technology.

Additional Resources

Methods That Matter
Daniels and Bizar
Published by Stenhouse Publishers, 1998.

Understanding by Design
Wiggins and McTighe
Published by the Association for Supervision and Curriculum Development, 1998.

Best Practice: New Standards for Teaching and Learning in America's Schools
Zemelman, Daniels, & Hyde
Published by Heinemann, 1998.

Glossary

Agriculture: The process of raising crops and animals for food, fuel and other useful products.

Anthropometrics: The study of human body size and motion.

Assessment: Process involving a variety of means for measuring student's knowledge and skills in a subject area.

Benchmark: A statement that describes specific knowledge and abilities that enable a student to attain the standards.

Biotechnology: The use of living organisms, or parts of organisms, to make or modify plants or animals, or to develop microorganisms for specific uses.

Computer-Aided Drafting: Use of a computer to generate, store, retrieve, and plot technical drawings to communicate ideas.

Construction: The process of developing structures, such as buildings and bridges.

Content Standard: A written statement about what students should know and be able to do.

Controls: Mechanisms or activities that use information to cause change in systems.

Curriculum: A plan for delivering content in the classroom.

Design: An iterative decision-making process in which plans are produced and implemented to devise an effective solution to problems or to meet identified needs and wants.

Discovery: An insight into the existence of something previously unknown. The act of finding out something new.

Hydroponics: A technique or system for growing plants without a soil medium.

Informational Technology: Processes associated with generating, storing, retrieving, transferring, and modifying information and data.

Innovation: An improvement of an existing product, system, or method.

Intermodal Transportation: Using more than one form of transportation to move goods.

Invention: Creation of a new product or system that has never existed before.

Manufacturing: A set of processes associated with making a product from raw materials.

Mathematics: The science of patterns and the study of measurements, properties, and the relationships of quantities.

Medical Technology: Use and advances in technology related to the study and practices of medicine.

Model: A visual or mathematical representation of an object or design.

Optimization: The processes involved in designing and making products and systems to be as effective as possible.

Portfolio: An organized set of student materials that documents research, designs, thinking processes, and activities associated with an experience.

Problem Solving: A decision-making process that begins with identification of a problem and results in one or more effective solutions.

Processes: A sequence of actions that combine resources to produce an output.

Prototype: A full-scale, working model used to test a design.

Requirement: Desired element or limitation of a design.

Resource: Things needed to get a job done.

Science: The study of the natural world.

System: A group of interrelated parts or elements that function together to accomplish a goal.

Technological Literacy: The ability to understand, use, manage, and assess technology.

Technology: Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend capabilities.

Technology Education: A formal study of technology, in which students learn about the processes and knowledge related to technology that are needed to solve problems and extend capabilities.

Thematic Unit: Classroom instruction organized around specific content and learning experiences related to a topic. Several content areas may be integrated in a thematic unit.

Trade-off: A decision involving one quality selected over another.

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